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BOSTON, MASS.

I. Ankylosis of the Elbow

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ANKYLOSIS OF THE ELBOW

WITH REPORT OF FOUR CASES TREATED BY ARTHROPLASTY*

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Ankylosis of the elbow is probably more objectionable than ankylosis in any other joint in the body. Elsewhere, while stiffness is objectionable, there is, nevertheless, an advantage gained in obtaining stiffness in a good position, more particularly in the hip and knee joints. In the hip, for example, we try to get extension and abduction, realizing that flexion and adduction are deformities interfering with function. In these joints, the end-results of arthroplasties are not so certain. In the elbow, however, there is no position in which ankylosis will not interfere with function.

Ankylosis is in the main the result either of infection or of trauma. The former may be caused by various organisms. When the onset is sudden and the course severe, the causative agent is usually the pneumococcus, gonococcus or streptococcus. Ankylosis may, however, result from a polyarticular arthritis, of insidious onset and progressive course. In the former, the resulting ankylosis is usually bony; in the latter, at least at first, it is fibrous.

Following trauma the ankylosis is commonly the result of a dislocation fracture with wide displacement. The ankylosis result is in this case due to mechanical interference. The hematoma formed at the time of the trauma organizes, forming considerable exuberant tissue; ankylosis finally resulting is fibrous.

Various methods have been tried to remedy this ankylosis. Wolff attempted to correct the deformity by removing all the exuberant tissue. This method has usually been attended by poor results, owing largely to the inaccessibility of the part and difficulty of approach.

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* Read before the Section on Orthopedic Surgery at the Sixty-Fifth Annual Session of the American Medical Association, Atlantic City, N. J., June, 1914.

Various foreign substances have been used by different men to separate the parts. Gluck used ivory pegs, Pupovac magnesium sheets, Baer[1] chromicized animal membrane. These have been found unsuccessful and have been largely abandoned. The inabsorbable material acts as a sequestrum and later gives rise to irritation. The Baer membrane has not been successful in my hands because of reankylosis after the rapid absorption of the membrane.

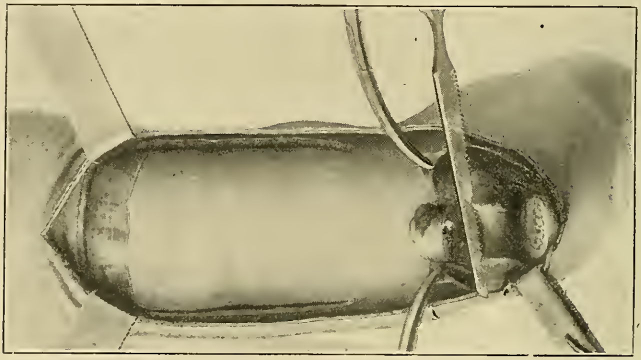

Fig. 1.—Arthroplasty (Murphy). Skin and fat dissected to either side. Fat flap below skin to triceps elevated. Ulnar nerve dissected out and retracted by gauze. Olecranon tip sawed through and pushed up. End of humerus being sawed off.

The interposition of soft tissues was first used in a case of temporomaxillary ankylosis in 1893 by Helferich,[2] who interposed part of the temporal muscles.

In the elbow the first operation on record is that of Quenu[3] in 1902, who resected extensively the inferior end of the humerus and the superior end of the forearm, and detaching the anterior ligament and doubling it with a few fibers from the brachialis anticus, fixed it against the bony surface of the humerus with three sutures to the fibrous posterior parts, keeping the parts in plaster fifteen days. He reported a good functional result.

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[1] Baer: Am. Jour. Orthop. Surg., 1909-1910, vii, 1.
[2] Helferich: Verhandl. d. deutsch. Ges. f. Chir., 1894, xxiii, 504.
[3] Quenu: Bull. et mém. Soc. de chir. de Paris, 1902, xxviii, 724.

Albarran[4] reported a case in which ankylosis had followed operative reposition. A partial resection was then done by which a good immediate result was obtained, but later reankylosis occurred. A third operation was undertaken which consisted of a resection of the olecranon and interposition of a muscle fascia flap of the triceps. After two years, there was a range of active motion from 65 to 115 degrees. Extension was possible without the aid of gravity.

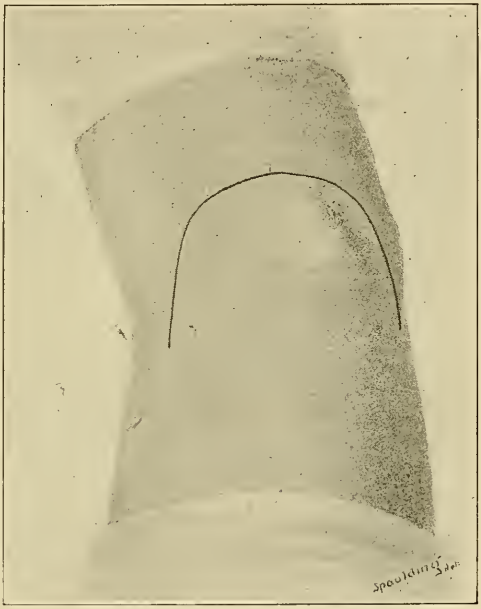

Fig. 2.—Line of incision.

Pronation and supination were normal. There was no lateral motion.

Nélaton,[5] in a case of ankylosis following a neisserian infection, resected an elbow and interposed a flap of the brachialis anticus. Two years after the operation, flexion and extension were normal, but pronation and supination were much decreased. Active extension required the weight of gravity.

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[4] Albarran: Cited by Hoffa (Footnote 11).
[5] Nélaton: Bull. et mém. Soc. de chir. de Paris, 1902, xxviii, 687.

In 1903, Quenu[6] reported an arthroplasty of the elbow for an ankylosis following a severe trauma of the arm, consisting of a fracture of both bones of the forearm and destruction of the soft parts. After resection, he interposed a tendon fascia flap. There resulted flexion to a right angle and good but incomplete extension. There was good pronation but difficulty in maintaining an intermediate position. The patient died a few months after the operation of pulmonary tuberculosis.

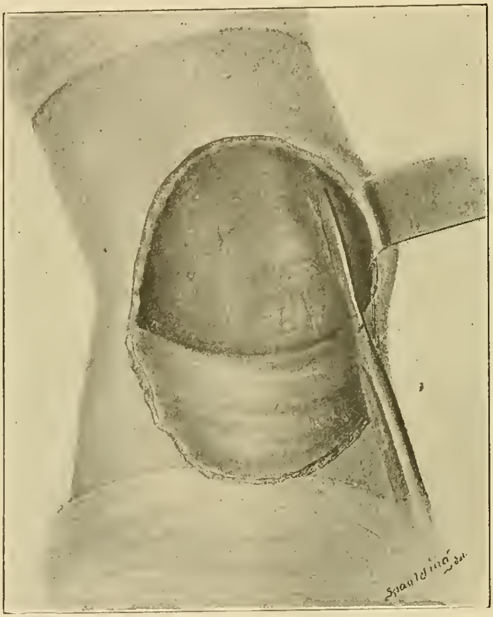

Fig. 3.—Dissecting out ulnar nerve.

Delbet[7] also reported mobilizing an elbow in a girl of six which had become ankylosed in infancy, resulting in complete atrophy of the arm. At his first operation he resected the joint without breaking up the ankylosis. Two months later, after reankylosis, he intervened again, removing the bony spicules that had formed and 0.5 cm. thickness from the humerus, the radius and the ulna, and interposing some fibers of the flexor carpi ulnaris. Chloroform mobilization was necessary a month later, but the final result was good, with flexion to a right angle and extension nearly complete.

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[6] Quenu: Bull. et mém. Soc. de chir. de Paris, 1903, xxix, 112.
[7] Delbet: Bull. et mém. Soc. de am. de Paris, 1903, n. s., xxix, 1172.

Berger,[8] in the same year, mobilized a fibrous ankylosis by remodeling the bony parts and inserting a flap of the anconeus which he sutured to the brachialis anticus. He had not at the time of his report obtained active motion.

Schanz,[9] in 1904, reported a mobilization of a bony ankylosis following rheumatism. After chiseling through the joint, he enlarged the sigmoid fossa, removed a piece of the trochlea, and interposed a flap of fat from the under side of the forearm. Three months after the operation the arm could be used for ordinary purposes.

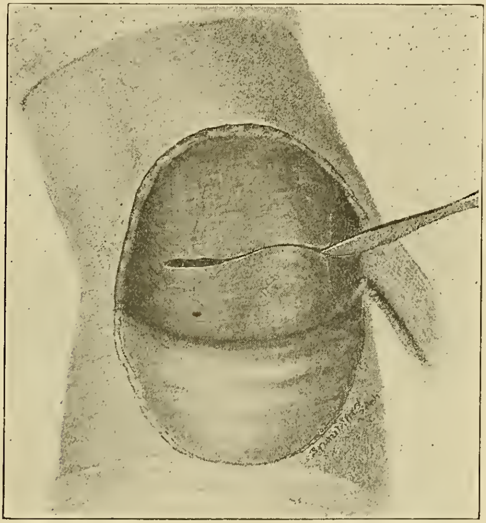

Fig. 4.—Cutting through muscle and fascia to joint.

Murphy[10] first used his fascia method in October, 1901, on a knee joint. A large layer of fascia lata with a thin layer of muscle tissue attached was dissected from the outer surface of the vastus externus, with its base below and anterior. A small flap of fascia covering the vastus internus was dissected free and placed between the patella and the femur. He first mobilized the elbow by this method in 1904 in a case of ankylosing arthritis. A pyriform flap of deep fascia was dissected from the posterior surface of the triceps. The flap was 4½ inches long by 2 inches wide at its upper end and received its blood supply from a broad pedicle which remained attached to the muscle and fascia just below the level of the olecranon.

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[8] Berger: Bull. et mém. Soc. de chir. de Paris, 1903, n. s., xxix, 998.
[9] Schanz: München. med. Wchnschr., 1904, p. 2228.
[10] Murphy, N.: Tr. Am. Surg. Assn., 1904, xxii, 313.

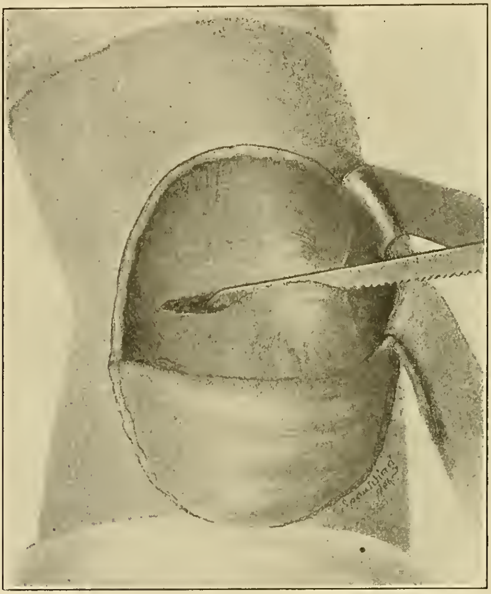

Fig. 5.—Sawing through olecranon tip and end of humerus.

After the bony parts had been remodeled, the fascia was drawn down and turned onto the joint around the inner margin of the olecranon. The proximal portion of the flap covered the trochlea and lined the olecranon depression and the lesser sigmoid cavity, while the distal portion covered the external condyle. Subsequent events showed that the flap was not carried sufficiently high on the anterior surface of the humerus to permit adequate flexion of the joint. Five months later, the patient could pass his hand through an arc of 5 inches. Pronation and supination were about one-half normal. His second case was reported two months after operation. The hand could be moved actively through an arc of 3 inches and the elbow forcibly flexed to an acute angle and extended to 160 degrees. Pronation and supination were approaching normal.

Hoffa[11] in 1906, reported a series of arthroplasties, seven of which were on the elbow. In one a magnesium plate was used. This operation was unsuccessful owing to the formation of gas in the joint, causing a fistula which closed only after the removal of the plate. The other operations in which fat, fat and fascia, or fascia flaps were used, were all successful. In two of these cases, the ankylosis followed scarlatina in the others gonorrheal infection.

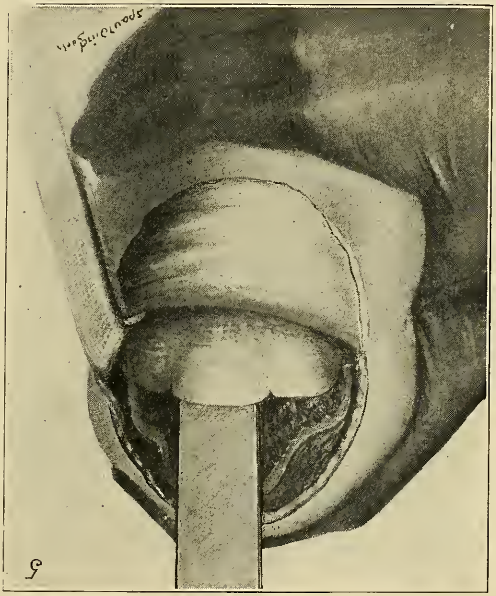

Fig. 6.—Splitting off tip of olecranon with chisel.

In 1905, Quenu[12] reported a third case in which there was great atrophy of the muscles. He used for a flap the inner part of the triceps sutured to the anterior ligament. Passive movements were begun in

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[11] Hoffa: Ztschr. f. Orthop. Chir., xvii, 1.

[12] Quenu: Bull. et mém. Soc. de chir. de Paris, 1905, n. s., xxxi, 622.

ten days, and later electrical treatment was used; but as active motion was incomplete at the end of two months, he made a second intervention to recover a part of the tendon of the triceps, a large portion of which had been sacrificed. He cut the portion interposed close to the bone. He could then ascertain that there was no adherence between the superior surface of the interposed segment and the inferior cut surface of the humerus. The same condition obtained on the inferior surface. The tendinous segment had left a distinct cavity. The tendon of the triceps was sectioned and reinserted on a little fibrous flap previously dissected on the forearm. The patient gained not quite complete extension and flexion to a right angle.

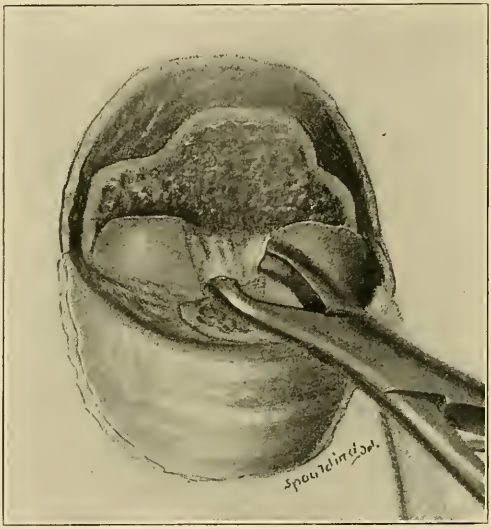

Fig. 7.—Cutting out with rongeur forceps bit of olecranon tip left in humerus.

Dupuy,[13] in 1905, reported five arthroplasties. Three of these were done by Jeannel, one by Kirmisson, and one by Launay. Jeannel used flaps of the brachialis anticus, Kirmisson of the biceps, and Launay a flap from the anterior ligament and the brachialis anticus. In all good results were obtained. In two of Jeannel's cases normal movements were obtained; in the other the degree of motion was less, but satisfactory function was gained. In Kirmisson's case all the movements were present and the function good, five months after the operation. Launay obtained passive motion from 80 to 155 degrees with free pronation and supination five months after the operation.

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[13] Dupuy: Thèse Toulouse, 1905.

In 1906, 1907, and 1908, Scudder[14] reported several cases in which he used Murphy's method successfully.

Pereira[15] in 1906, in an unreduced subluxation, resected the ends of the bones and interposed a flap of triceps muscle with almost perfect functional result.

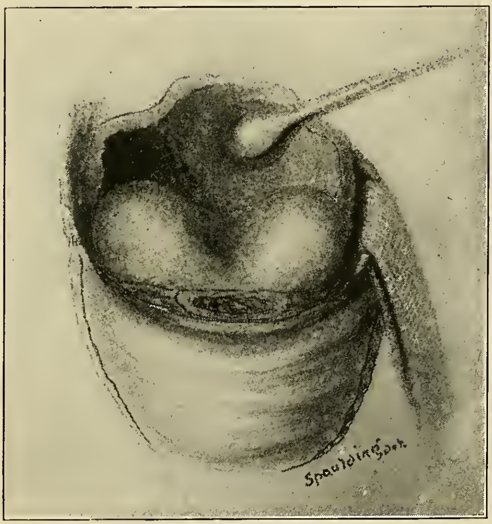

Fig. 8.—Scooping out ulna and radius with curet.

Hofmann,[16] in 1906, reported a case in which he transplanted periosteal flaps from the tibia to the resected ends of the bones of the elbow. He obtained full extension and flexion to 80 degrees. Pronation and supination were unimpaired.

Bazy[17] in 1907 mobilized an elbow, using a flap from the brachialis anticus. Nine months later the function of the arm was almost perfect.

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[14] Scudder: Boston Med. and Surg. Jour., 1906, clv, 375; Ann. Surg., 1907, xlv, 297; ibid., 1908, xlvii, 711.

[15] Pereira: Brazil med., 1906, xx, 361.

[16] Hofmann: Chir. Kong. 1906, Zentralbl. f. Chir., 1906, 16.

[17] Bazy: Bull. et mém. Soc. de chir. de Paris, 1907, n. s., xxxiii, 520.

The same year, Stein[18] reported three cases from Bier's clinic in which triceps flaps were used. All were successful.

In 1909, Huguier[19] reported an ankylosis which he mobilized, using a flap of brachialis anticus. Sixteen months later, the patient could touch his shoulder with his hand and extend his forearm to 150 degrees.

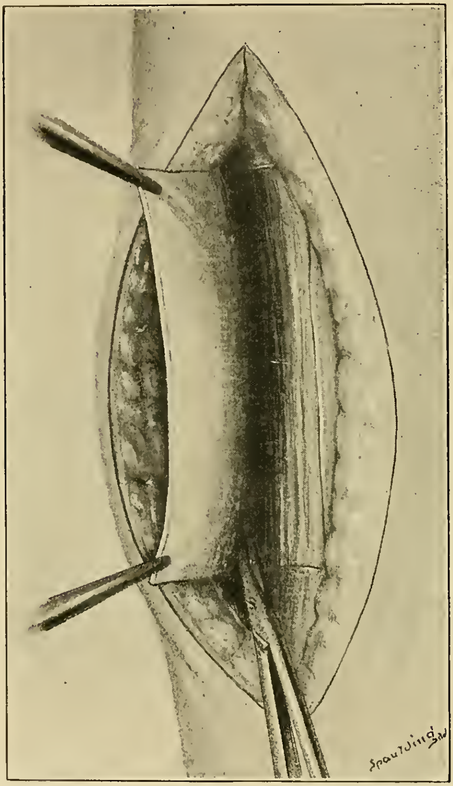

Fig. 9.—Cutting fascia lata from thigh.

Cifuentes[20] reported in the same year a similar arthroplasty in which he obtained a month after the operation a good functional result with normal movements.

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[18] Stein: Diss. Bonn, 1907.
[19] Huguier: Tribune, méd., 1909, n. s., xli, 197.
[20] Cifuentes: Rev. espec. Méd., Madrid, 1909, xii, 73.

In 1910, Reiner[21] reported a series of twenty-eight arthroplasties, twenty-five of which were given in full with the after-results. Two others, recent cases, were reported with good immediate results. In three others, the histories were unknown. Of the others, nineteen gave useful arms although one was a flail joint which lacked power but could be controlled by the muscles. The poor results were due in one case, a fracture luxation, to extreme atrophy of the muscles, in a tuberculous case to extensive resection of the disease tissue necessary, resulting in a useless flail joint. Reankylosis occurred in two cases. In one, it was due to operation too soon after trauma, a fracture luxation, and lack of after-treatment. In the other case, the author attributes the result to the disease, myositis ossificans.

Thom[22] reported in 1910 a case of ankylosed elbow operated on by Rittu. He used freely transplanted fascia lata as an insert after the parts had been made freely movable. On discharge, there was 65 degrees flexion and 100 degrees extension. Pronation and supination which were very slight before the operation were unchanged.

Wille,[23] in 1911, interposed supinator longus fascia with good result, gaining 95 degrees motion.

Whitman[24] reported two cases of arthroplasty of the elbow in which he used Murphy's method.

In 1912, Edmunds[25] reported an elbow ankylosis following fracture in which this method was likewise used. At the time of the report, active motion was not possible on account of the great atrophy of the muscles.

Denk[26] reported two cases of von Eisenberg in which elbow joints were mobilized with free fascia transplants with good functional results.

Neff[27] reported a case in which he interposed a pedunculated triceps aponeurosis flap between the humerus and ulna and the radius and ulna. Seven months after the operation, there was active painless motion of 180 degrees to 30 degrees and only slight lateral mobility. The joints of the wrist and hand, which were previously partially ankylosed, regained from a third to a half their normal range of mobility with the return of function to the elbow.

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[21] Reiner: Deutsch. Ztschr. f. Chir., 1910, civ, 209.
[22] Thom: Deutsch. Ztschr. f. Chir., 1910-1911, cviii, 424.
[23] Wille: Norsk Mag. f. Læger., 1911, 5 R., ix, 40.
[24] Whitman: Ann. Surg., 1911, liv, 860.
[25] Edmunds: Med. Press and Circ., 1912, xciv, 574.
[26] Denk: Arch. f. klin. Chir., 1912, xcvii, 458.
[27] Neff: Surg., Gynec. and Obst., 1912, xv, 529.

Delbet, in 1912, reported having done nine resections of the elbow with articular grafts. Most of these were too recent to determine the results, but he reported in detail two cases which were of a year's duration and appeared permanent. In one of these he used cartilage from an ankle joint, in the other, cartilage from an elbow. Both gave good functional results.

Caput[28] reported a case in which he resected a flap of fat the size of the palm from the thigh and encapsulated the lower end of the humerus with it, suturing it to the neighboring muscles by anteroposterior and lateral sutures.

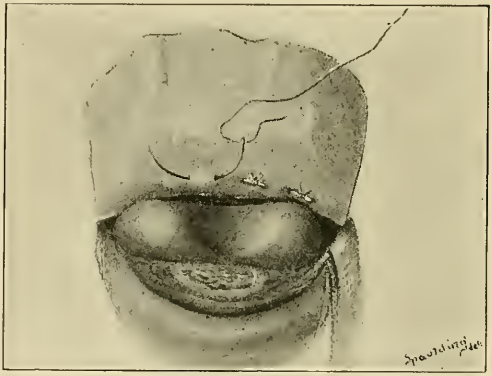

Fig. 10.—Sewing fascia lata to elbow joint anteriorly.

Recently Murphy[29] reported among a series of arthroplasties done by him twelve on the elbow by his pedunculated fat fascia flaps.

Roppe[30] reported the use of free fat transplant on the elbow with good result.

Greiffenhagen[31] reported three cases in which periosteal flaps were used to separate the ends of the bones. The periosteal grafts were taken from the tibia.

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[28] Caput: Bull. et mém. Soc. de chir. de Paris, 1912, n. s., xxxviii, 452.

[29] Murphy, N.: Ann. Surg., 1913, lvii, 595.

[30] Roppe: Deutsch. chir. Kong., 1913, p. 116.

[31] Greiffenhagen: St. Petersburg med. Ztschr., 1913, xxxviii, 93.

Mauclaire[32] mobilized an elbow, using cartilage from the astragalus to cover the defects. One fragment was put on the lower end of the humerus, another between the radius and ulna. The Roentgen ray later showed these grafts fused to the bone.

Osgood[33] recently reported sixteen attempts at mobilization by various methods in the different joints, many of which were unsuccessful, and he advises against arthroplasty in the hands of untrained operators.

I have not included among these cases the various attempts at mobilization of elbow joints by the use of inorganic substances or animal tissues. The earliest operation of this sort was that of Pupovac, who reported an operation performed in 1901. He used a magnesium plate between the ends of the bones. He attributed his poor result, 21 degrees motion, to lack of after-treatment, but the operation has not met success owing to the formation of gas fistulas, as in the case reported by Hoffa.

Baer used chromicized pig's bladder, and in his report gives a case in which he gained 110 degrees motion in an elbow joint. Regarding the use of this tissue, I will speak later of the experimental work of Brooks and Allison.[34]

König uses ivory prothesis in extensive operations in the joints as well as in the shafts of bones. He finds that the surrounding soft parts and the bone enter into intimate union with the ivory and that bone gradually replaces it. In a case of spindle-cell sarcoma, he gained 135 degrees extension, 85 degrees flexion and complete rotation.

De Amezaga used a temporary packing of gauze to separate the cut bones, gaining 114 degrees motion, and Taylor[35] uses a mixture of yellow wax and lanolin for the same purpose.

The use of fascia for transplants has not been confined to its use in joints, but it has been used both experimentally and clinically in various tissues. Before considering the experimental work of Murphy and others on the use of fascia in joint, I will mention briefly the findings in its use in other parts of the body and the clinical results reported.

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32. Mauclaire: Bull. méd., Paris, 1913, xxvii, 66.
33. Osgood: Surg., Gynec. and Obst., 1913, xvii, 6.
34. Allison and Brooks: Surg., Gynec. and Obst., 1913, xvii, 645.
35. Taylor: New York Med. Jour., 1913, xcvii, 1113.

Kirschner,[36] in 1909, reported experiments on dogs and rabbits in which he successfully transplanted fascia into prepared defects in fascia, muscle and dura and used it to lengthen tendons and for covering the injured surface of the liver to control hemorrhage. In all these experiments, he found that the fascia remained alive and gained its nutriment from the surrounding tissues.

Von Saar[37] used various tissues experimentally to correct dural defects, but found the best results from fascia and hernial sac. On microscopic examination, he found that the tissue remained unchanged at the periphery, but in the center fatty degeneration took place, a condition not found by other experimenters.

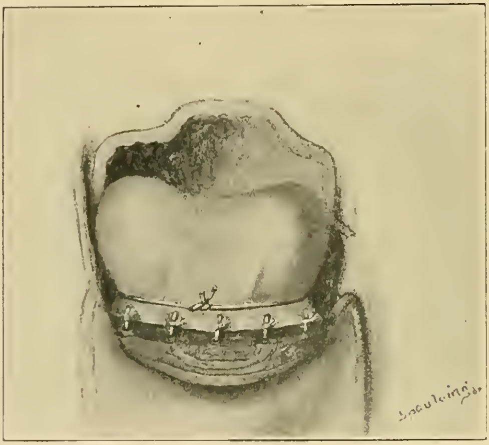

Fig. 11.—Fascia sewed over humerus; tied with kangaroo suture.

Lewis and Davis[38] reported five transplantations into the subcutaneous tissue with similar results. They found that unless the fascia was sutured in place it rolled up and atrophied.

König[39] used fascia to strengthen stitches in hollow organs lined with endothelium and to bridge over visible defects in the bladder, intestine and stomach. He found after three months that the fascia retained its structure.

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[36] Kirschner: Beitr. z. klin. Chir., 1909, lxv, 472.

[37] Von Saar: Beitr. z. klin. Chir., 1910, lxix, 740.

[38] Lewis, Dean, and Davis, Carl B.: Experimental Direct Transplantation of Tendon and Fascia, The Journal A. M. A., Aug. 12, 1911, p. 540.

[39] König: Arch. f. klin. Chir., xcv, 326; München. med. Wchnschr., 1913, lx, 1136.

Hohmeyer[40] extended the use of fascia to organs without serous coverings, as the esophagus. He used it also on the trachea and bladder.

Davis,[41] in 1911, reported the use of fascia which had been kept in sterile fluid from two to thirty-five days. He transplanted fascia into almost every tissue and found it later in cases in which there had been no infection living and retaining its identity. In some of these experiments the fascia was drawn taut around rubber tubes and inserted in various tissues. He reported the use of fascia in an arthroplastic experiment in which he found the fascia at necropsy unchanged. This result was probably due to the fact that the tissue had been functioning a very short period, as the animal died three weeks after the operation.

Rehn[42] in a report to the congress of German surgeons in 1911 stated that a difference between homoplastic and autoplastic tissue did not exist.

Levit[43] reported the use of fascia repairing defects in the abdominal wall, and Valentin,[44] in the same year, ten experiments on rabbits and dogs to repair abdominal defects, in two of which he used homoplastic tissue; in one experiment he removed the entire abdominal wall except the skin and peritoneum.

Kostenko and Rubaschow[45] reported from Martynow's clinic, sixty-five experiments. In a series of twenty, they found that fascia could be used on the bladder to strengthen stitches and to close small fistulas, but that in large fistulas its use was not practicable as necrosis took place in the center of the fascia. In a series of fourteen experiments, he found a similar result with the esophagus. He described six successful attempts to bridge over tracheal defects 2 cm. in diameter. In these, he did not observe the overgrowth of connective tissue noted by Hohmeyer and Davis. He also used fascia to cover stitches in the ureter in blood-vessels. In one case in each of these a stitch became loosened and yet the fascia held its position. He transplanted fascia also into the subcutaneous tissue, into the dura, and the abdominal wall, and the Achilles tendon, and surrounded nerves with it. His histologic researches showed that the fascia at first became edematous and showed increase of leukocytes, but later returned to normal condition. The experiments extended over a comparatively short time, two months.

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[40] Hohmeyer: Arch. f. klin. Chir., xlv, 345.
[41] Davis: Ann. Surg., 1911, liv, 734.
[42] Rehn: Deutsche chir. Kong., 1911, 87.
[43] Levit: Arch. f. klin. Chir., 1912, xcvii, 686.
[44] Valentin: Deutsch. Ztschr. f. Chir., 1912, cxiii, 398.
[45] Kostenko and Rubaschow: Russ. Chir., 1911 (by Kornew).

Kornew[46] reported fifty experiments on dogs and cats. These were divided into three series, the substitution of fascia for tendon defects, pleural defects and defects in the abdominal wall. In the first of these, he found that the fascial transplant acted at first mechanically and that it was later replaced by connective tissue. At the end of three months the difference between graft and tendon had almost disappeared. In the pleural transplant, he found that large defects (from 6 to 8 cm.) could be filled by fascia. The fascia became covered by scar tissue and on the inner side by flat pleural cells. Connective tissue prolifer-

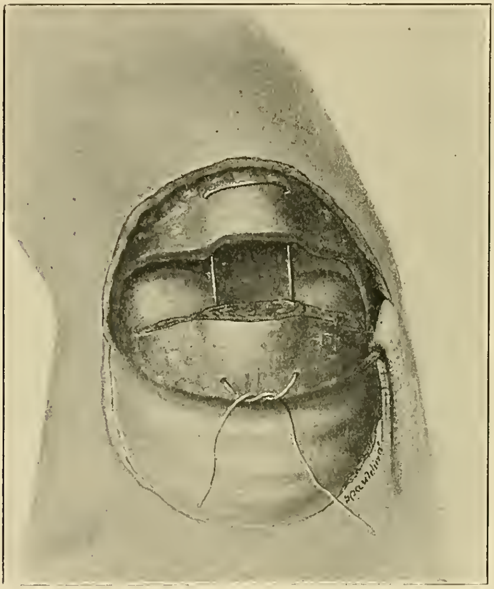

Fig. 12.—Kangaroo suture through ulna and olecranon tip.

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[46] Kornew: Beitr. z. klin. Chir., 1913, lxxxv, 91.

ated into the profascial and endofascial layers, but the true fascial bundles do not lose their structure even after the lapse of a year. He also covered abdominal wall defects with fascia with excellent results.

Joffe recently reported experiments on cats, transplanting fascia to the stomach, colon and liver. When the mucous membrane was sutured first, the results were always good.

Successful use of fascia in twenty-six experiments has been recently reported by von Eberts.[47] These were in defects prepared in the Achilles tendon, the dura and the peritoneum.

Kornew also collected eighty cases found in literature. The largest number of cases, twenty-six, were those in which the fascia was used to close dural defects. Since then Lucas[48] has reported twenty-nine cases. Previously he had reported five. It has been used fifteen times in closing hernias. In addition, he reported twelve cases of inguinal hernias, one hernia cruralis and one hernia pulmonalis. He found three cases in literature in which fascia had been used to correct paralyzed muscles. He found thirteen reports of its use to mobilize joints, and reported one case of his own. It has also been used to correct flatfoot, to cover a tendon sheath, and to cover an amputation stump. It has been used in prolapsus recti instead of the Tiersch metallic ring, in retention of the testis, to check hemorrhage in rupture of the liver and to isolate nerves. It has been used to close the fistulas, and recently Smuch reported a case of vesicovaginal fistula closed by a free fascial flap. Von Eberts reports repairing a defect in the abdominal muscles following appendectomy. Wilms used fascia to close the pylorus in ulcers of the duodenum. Success has also followed the use of fascia to cover stitches in the hollow organs and to cover defects in various organs as the trachea, pleural cavity and urethra.

In the experimental work reviewed above we find that the transplanted fascia retains its characteristics, even after a considerable period of time. In the mobilization of joints the ultimate fate of the fascia is different. Here we have the additional elements of pressure and the sliding of the joint ends over the fascia.

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[47] Von Eberts: Surg., Gynec. and Obst., 1914, xviii, 318.
[48] Lucas: Deutsch. chir. Kong., 1911, 105.

Murphy in his article on arthroplasty first advocated the use of fat and fascia interposed between joint surfaces. The fundamental point in his work is that fatty tissue forms connective tissue under pressure. The bursa formation is due to the absorption of fat from fatty tissue, and to the coalescence of the small fat capsule, with hyperplasia of the connective tissue and its degeneration with the development of collagen, the liquefaction of which in the center forms the fluid of the bursa. The aponeurosis, therefore, according to Murphy, to be used in artificial joints must have plenty of fatty tissue. He demonstrated on a dog, four months after operation, the formation of such a sac with lining membrane, resembling endothelium from the fascia interposed between the head of the femur and the acetabulum.

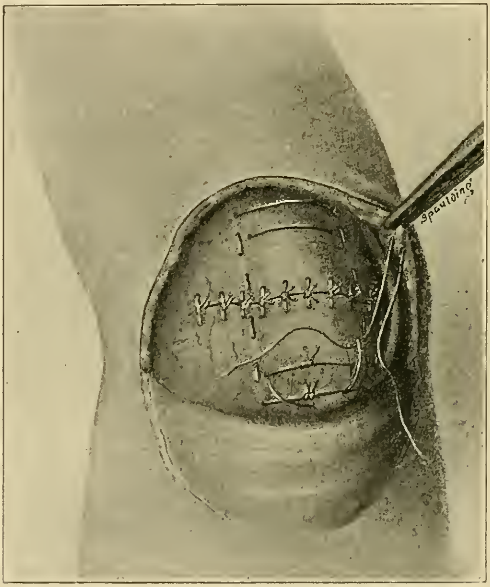

Fig. 13.—Stay sutures.

Sumita,[49] in his experiments on dogs, interposed muscle and tendon as well as fascia in joints and found no marked difference resulting from the tissue used. He found that the transplant underwent degeneration in the center, leaving a cavity which he thought to be like a ganglion rather than a bursa. He described the transplant as clinging to the bone surfaces and preventing growth of bone.

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[49] Sumita: Arch. f. klin. Chir., 1912, xcix, 755.

Neff described an experiment in which he removed the cartilage from the lower end of the femur and the upper end of the tibia and interposed a flap of rectus fascia between the bones. He also covered the patella surface of the femur with fascia. Four months after operation the knee joint showed the capsule reformed and the tibia and femur separated by a pad of connective tissue which was firmly united to the bony surfaces above and below. In the center of the connective tissue pad were two bursal sacs, each ½ inch in diameter and filled with a clear, thick fluid resembling the contents of a ganglion. These were at the points of greatest pressure. Their walls were of fibrous connective tissue, which, on the inner side, had become more closely packed but showed no evidence of flattening.

Allison and Brooks recently reported a series of experimental arthroplasties, the object of which was a comparative study of the value of various tissues for inserts. As a basic experiment, they removed the cartilage from the joint surfaces of the knee and closed the joint without interposing anything. Ankylosis quickly took place.

They found that Cargyle's membrane persisted in the joint for less than ten days and that after its use the opposing surfaces became united by granulation tissue. With the use of free fascia they found that no local reaction took place. In one experiment, it was found that the fascia had entirely disappeared by the twenty-ninth day. In another, after twenty-two days, a small portion remained that showed microscopic evidence of rapid degeneration. In another, after thirty-one days, the transplant persisted only in small islands which were attached to the joint surface and which preserved the histologic characteristics of fascia, appearing as adhesions rather than joint coverings. The joint surfaces had been covered over with newly formed connective tissue, arising from the marrow spaces.

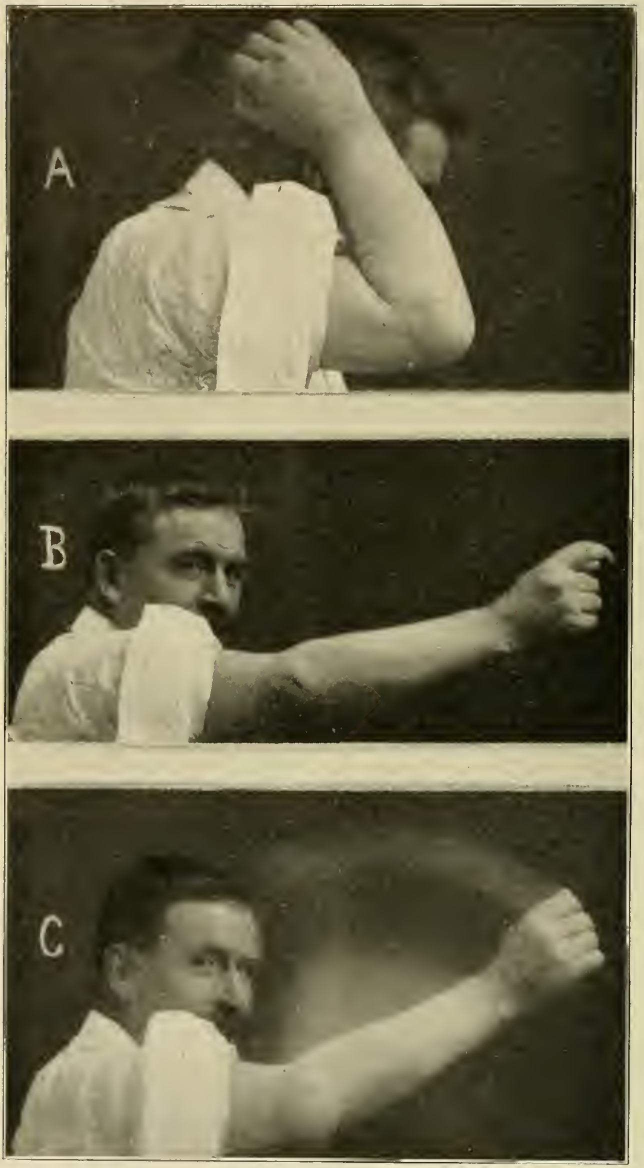

Fig. 14.—Ankylosis of the elbow: *A,* volutary flexion following arthroplasty; *B,* volutary extension following arthroplasty; *C,* voluntary flexion and extension following arthroplasty.

When a pedunculated flap was used, the interposed fascia acted identically. The peduncle persisted as a band between the proximal margin of the denuded surface and the site of the operative incision.

The use of chromicized pig's bladder (Baer) resulted in marked local reaction. The tissue was present in the joint in one experiment after twenty-eight days. In another, it had totally disappeared after forty days. The local reaction resulted in newly formed connective tissue greatly in excess of that seen in any other experiment. In the cases in which the transplant had been absorbed, it had bound together the opposing surfaces.

When fascia impregnated with silver nitrate was used, there was no marked local reaction. At the end of thirty days, the fascia was found absorbed. In only one case were adhesions found, and these were slight in extent.

Two experiments were undertaken also, in one of which simple fascia and in the other fascia impregnated with silver nitrate were placed in soft parts. The simple fascia was found on the twenty-ninth day healed in so that it was continuous with the surrounding tissue. The silver-impregnated fascia was found after thirty-seven days to be almost entirely absorbed, leaving a cavity, the walls of which showed no evidence of closing in.

The authors conclude that a pedunculated flap has no advantage over a free one and that the best results are obtained by impregnating the fascia with a new irritating substance as silver nitrate.

I believe from my experience thus far that there are certain objections in dealing with the fatty tissue used by Murphy, such as embolus, fatty necrosis from poor circulation and as happened in Cases 1 and 2, skin necrosis due to the use in the flap of the tissue holding its blood-supply. I, nevertheless, report these cases, citing my fat and fascia method in the first two and the transplantation of fascia lata in the third and fourth, a procedure much more surgical in appearance and with development in technic I am sure more satisfactory in final results.

Case 1.—M. R., woman, aged 34, referred by Dr. Hussey of Holyoke. Family history negative. She has had attacks of rheumatism for the last thirteen years, affecting ankles, elbows and knees. These were affected nine years ago, and were operated on one year later. The right wrist was attacked five years ago, the left wrist and knee six months ago. Examination revealed a well-developed and nourished woman. Heart and lungs negative. Right knee ankylosed

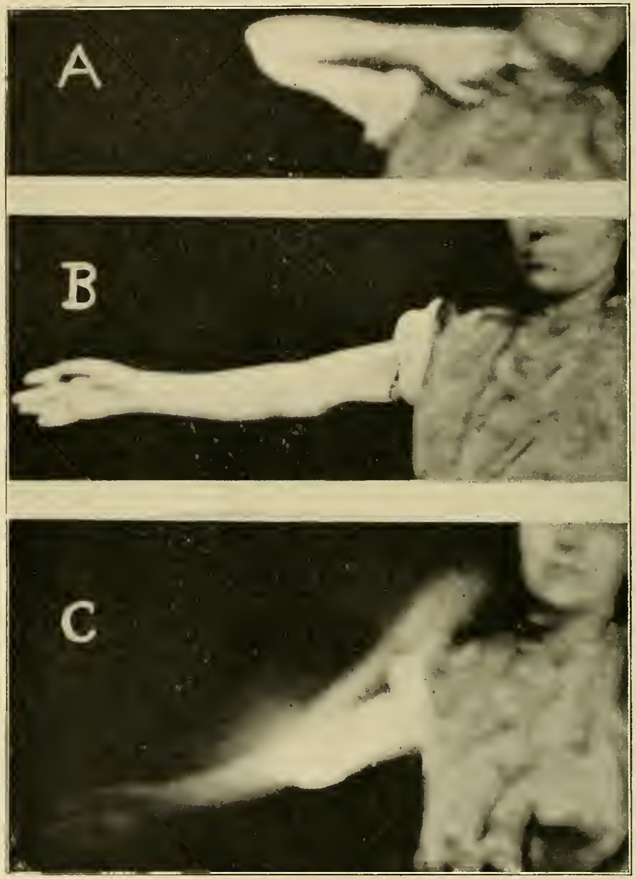

Fig. 15.—Ankylosis of elbow, six months after arthroplasty; *A,* voluntary flexion; *B,* extension and use of arm; *C,* voluntary flexion and extension and power of biceps.

with scars on either side. Both knees slightly flexed. Right ankle, contractures. Ankylosis with some contracture of the Achilles tendon. Right elbow ankylosed in about 125 degrees. Left elbow, motion good with exception of 10 degrees limitation in extension. Patient was admitted to the orthopedic service of the Carney Hospital, Sept. 6, 1910, and received rest, compression strapping for the knees, and spiral strapping for the feet, together with aspirin and flannel bandages. Under this treatment very slight improvement took place in the knees and feet. In October, on account of the swelling and bogginess of the left knee, an arthrotomy was advised.

October 19, ether operation, Dr. MacAusland. Incision about 4 inches long, on the inner side of the left knee, extending through the fascia and capsule into the joint. The synovial fluid was thickened and viscid, and a large lipoma present in the anterior part of the joint which was removed as well as many of the small fringes, and the joint washed out with salt solution. The incision was closed in the usual manner. Daily manipulations followed this operation, beginning on the fifth day, and an uneventful recovery took place as regards the knee.

As the right elbow was stiff and in a very ungainly position, an arthroplasty was advised. Nov. 9, 1910, ether operation, Dr. MacAusland. An incision was made extending from just below the right shoulder down the back of the arm to about 3 inches below the elbow joint (Fig. 1). The skin was dissected off at each side, and a large flap of fat and fascia just above the olecranon process freed. The right elbow joint was then opened by a transverse incision across the olecranon and through the capsule. The end of the humerus was excised and the radius and ulna rounded off with a file, making an artificial joint. The flap was then turned from the back of the arm to the inside of the joint and sutured there by heavy catgut, and the olecranon process with the triceps tendon was put through a slit in this fascia and united to the ulna by heavy chromic catgut sutures. The skin was closed with interrupted catgut, and silkworm-gut.

Nov. 10, 1910, the right hand was considerably swollen and painful, for which pressure and hot fomentations were applied. The skin on the upper part of the arm became somewhat necrotic from poor circulation and later sloughed.

November 21, the stitches were removed.

November 23, dry dressing, wound cleaned.

November 30, passive motions started daily. First attempt was made at motion, when 30 degrees were attained.

December 7, doing well; gaining motion gradually.

Dec. 24, 1910, massage to hand, forearm and shoulder.

Jan. 11, 1911, about 30 to 40 degrees motion in flexion and extension obtained. Heavy granulation tissue.

January 18, discharged from the house. Dressings to be done at home.

Feb. 28, readmitted to the house for manipulation. Normal motion was obtained.

March 13, 1911, discharged to continue with massage, manipulations at home. Since this time patient has been seen in the out-patient department. There is practically no lateral mobility, and the end-result is perfect function.

Case 2.—F. P., woman, fell and injured elbow, March, 1908. The injury was treated as a sprain and put in splints for about a week. The elbow was discolored and swollen. Liniments were prescribed for the stiffness with no effect. She was able to go back to work in the course of a few weeks, having only slight pain and stiffness, but as time went on, the motion shut down. She received osteopathic treatments for a month without any result. In 1908 she attended the hospital clinic, where roentgenograms were taken, and the arm kept under observation for six weeks. During this time the elbow seemed to be stiffening more and more. Patient entered the orthopedic department of the Carney Hospital, Nov. 17, 1908, and at that time had about 30 degrees motion, but was unable to flex the arm beyond a right angle.

Nov. 18, 1908, a 4-inch incision was made between the external condyle and the olecranon, and posterior displacement of the epiphysis of the humerus was found which, with the callus present, prevented extension. The projection of the humerus forward prevented the flexion beyond a right angle; as much as possible of the exuberant bone was removed.

Nov. 20, 1908, the second day after operation, she had a great deal of swelling and pain in the fingers. The plaster cast was therefore removed. Patient had lost all motion of the fingers owing probably to the forcible manipulation and the large amount of swelling. The plaster was unfortunately allowed to remain on for three days and a paralysis developed.

Dec. 2, 1908, patient was seen in consultation with Dr. Bullard, who considered the case one of Volkmann's paralysis.

Dec. 3, 1908, received daily massage and baking.

Feb. 9, 1909, entered the orthopedic service of the Carney Hospital and was recommended to have a manipulation under ether.

Feb. 10, 1909, ether manipulation, Dr. MacAusland. The right forearm was forcibly flexed and extended through an arc of about 60 degrees, during which the adhesions were felt to break up.

Feb. 14, 1909, the patient has gained about 15 degrees of motion but complains of some pain in the elbow and shoulder. From the time of the first operation, Nov. 17, 1908, until April, 1909, she could not move any of the fingers and there was no rotation. The first sensation of life came in the arm with a slight twiching of the fingers, April 2 and 3, 1909. She received daily baking and massage and passive movements from this time on. Gradually, through the summer months, she gained entire control of all the muscles of the forearm and fingers, although she had only a few degrees of motion in the elbow. This illustrates a splendid recovery from the Volkmann's paralysis, due, probably, to the efficient baking and massage, but, unfortunately, on account of sensitiveness of the elbow, there was not so much motion as before operation, so that an arthroplasty was thought advisable.

In December, 1909, the patient entered the orthopedic service of the Carney Hospital, and at this time an arthroplasty of the elbow was done according to method described in Case 1.

The circulation of the skin above the original site of the flaps became somewhat diminished and there was a small amount of sloughing. Wound was dressed each day, and about the fifth day daily movements were attempted. In the course of a month, massage and baking were again taken up, and continued until May, 1910. The result is that the patient has full motion of the arm in flexion, and extension to within 15 degrees of straight, and has a perfect functional hand, in spite of the slight limitation in extension, and uses the arm daily, being employed as a stenographer.

CASE 3.—D. W., man, aged 42, referred by Dr. Shea. Case operated before New Hampshire State Surgical Club. March 25, 1911, he received a contused wound of left thumb, which became septic, requiring, one week later, his entrance to hospital as the sepsis had become general. Five incisions were made in the left hand, two in the left wrist, one close to the left elbow joint, and one in the left hip. All had drains put in. A student in the hospital opened a swelling near the right elbow and cut into the joint. At the end of twenty-one weeks the patient was discharged from the hospital with bony ankylosis of the right elbow and with but a few degrees of motion in the left elbow. Both joints were slightly flexed. The left wrist had a sinus which still drained a little and he had little motion in the fingers, being unable to flex them to a right angle with the palm of the hand. He was unable to feed himself or to touch his head with either hand. He entered St. Joseph's Hospital a few weeks later and was operated on in March, 1912.

Operation was performed by Drs. MacAusland, Shea and Wallace. After the usual preparation and the application of a tourniquet, a U-shaped incision was made, beginning on the lateral aspect about 3 inches above the elbow joint, and passing over the middle of the olecranon to a corresponding position on the opposite side (Fig. 2). The skin and superficial fascia was dissected up to a base line at the end of the incision and then retracted. The skin and fascia were then dissected a little on both sides and on the forearm end of incision. The ulnar nerve was dissected out of its sheath, and gently retracted with gauze (Fig. 3). A straight incision was made extending from one lateral aspect of the condyle to the opposite, crossing midway on the olecranon (Fig. 4). As the capsule and fascia were adherent the incision was made down to the bone over the condyle so as to elevate *en masse* the tissue which would serve as a new capsule. The olecranon was then sawed across and separated (Fig. 5). Owing to the extensive bony ankylosis, even with extreme force the joint could not then be broken open so that it was necessary to saw directly across the line of the old joint. When about three-fourths through the joint, it was possible to fracture the remainder (Fig. 6). There was no doubt of its being a bony ankylosis.

The capsule and fascia and ligaments were dissected back so as to allow the lower end of the humerus to protrude out of the wound when its square edges were snipped off with a rongeur forceps and a new trochlear or intercondylar surface formed (Fig. 7). A shoemaker's rasp was used to file this extremity as near like a normal humeral end as possible. A piece was then removed corresponding to the olecranon fossa in the normal humerus (Fig. 8). After this was cleaned, the corresponding surface of the olecranon was curetted so as to take the new humeral head. This modeling of the joint I do largely with a saw and file. To insure good function, the joint surfaces should fit accurately before the fascia is applied, but the joint should not be too loose. Only sufficient bone must be removed to give free motion. If too much of the ends of the bones is removed, a flail joint will result, giving the operation no advantage over an excision. When this mortising was completed, the fascia flap was dissected out of the right leg.

A 5- to 6-inch incision was made on the outer side of the right thigh a little below the middle, extending down to the fascia lata. A piece was dissected out (Fig. 9) about 5 by 4 inches and the wound closed. This fascia, free from all fat, was placed about the new humeral condyles by attaching it first to the anterior capsule of joint (Fig. 10) and then tying it about the condyles so that all rough surfaces were covered and a purse-string suture was applied (Fig. 11).

The fascia ligaments and old capsule were then sutured with chromic catgut. The olecranon was sutured with double chromic catgut (Figs. 12 and 13). The skin was closed with silkworm-gut, and a voluminous dressing applied with the arm at a right angle. Arm and forearm were placed on pillows with heavy dressings but no splint. Passive motion was begun on fifth day. Primary union took place of the wounds of the elbow and thigh. Passive motions were continued and increased, but at the end of six weeks it was found that the patient could not use either biceps or triceps muscles and he had lost all power from long disuse. However, after several weeks he educated the muscles by counting and attempting contraction at the same time and finally was able to flex the forearm himself, since when improvement has continued.

Result: He has full motion in flexion, extension and rotation now, and is able to feed himself and to do chores about the house, and put on his own clothes.

Previous to operation, May, 1912, he was entirely helpless, unable to care for himself in any way. The first duty for every probationer in the hospital was to "feed D."

For the foregoing detailed report, I am indebted to Dr. A. W. Shea, Nashua, N. H.

Case 4.—E. S., woman, admitted to the Carney Hospital, Aug. 11, 1913, for immobility of the right elbow and right knee, of six years' duration. The patient states that while on a vacation she went in bathing while menstruating. Within twenty-four hours she was taken ill with a fever, accompanied by pain and swelling in all the joints. She was placed under treatment in her home without relief. At the end of eight months, the pain and swelling disappeared from the left shoulder and elbow so that she was able to feed herself. She remained in bed for twelve months. The symptoms continued to subside on the left side until at the end of the third year she was able to get about with a cane. As the fever continued to subside and the pain and swelling disappeared, the patient had pretty good motion in all the joints except the right elbow and right knee, in which pain and stiffness continued at the end of the fourth year and motion was out of the question. This condition remained up to the date of admission.

Aug. 14, 1913, roentgenoscopy revealed ankylosis of elbow joint and of patella to femur. Urine examination revealed specific gravity 1.015, acid; albumin 0, sugar 0.

Aug. 20, 1913, operation on right elbow by Dr. MacAusland, as in Case 3. Light plaster cast applied.

August 22, good recovery; slight pain.

August 27, cast split for dressing.

September 1, wound healed by first intention, except for slight discharge from upper border.

September 4, manipulations daily; motion good.

September 10, arm can be extended completely, and flexed 15 degrees beyond a right angle.

September 15, traction for extending and flexing the arm.

September 20, massage and motion continued.

October 1, active motion possible.

October 15, manipulation of elbow under ethyl chlorid by Dr. MacAusland.

Patient now has perfect flexion and extension and no pain. Excellent functional result.

240 Newbury Street.

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THE OPEN METHOD IN THE REDUCTION OF FRACTURES

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A DISCUSSION of the treatment of fractures, particularly the advancement in such treatment, is always of interest to the general practitioner, as well as to the surgeon, but probably no part of general practice is so much avoided, or at least accepted with as great hesitation. There has been a great deal written of late on fracture treatment. Many of these articles stand out as brilliant monographs, notably those of Lane, while others are recapitulations. It is, of course, impossible for me to discuss and illustrate more than certain lines of development in the treatment of fractures which I feel are of importance. We all have had certain principles in fracture treatment so thoroughly drilled into us in our school and hospital training that it is hard to accept new ideas, but with the progress of asepsis and operative technique much is being accomplished in surgery that has heretofore seemed hopeless. Within five years, surgeons have been considered radical who have intervened surgically in the treatment of simple fractures. I know, on the other hand, that many surgeons with little judgment and surgical skill have attempted the operative treatment of fractures, and, aside from frequently obtaining sepsis in the wound, have often added foreign material to suppurate later.

The method of reduction by manipulation, "closed reduction," is not without danger to vessels, nerves, and muscle, besides often not attaining the desired end; i. e., the return to proper alignment. As an illustration of this, take the usual fracture of the femoral shaft in which end-to-end apposition is rarely attained. There are out of a large proportion of fracture cases that one sees a certain percentage that have given unsatisfactory results by following this "conservative" method. It is concerning these types of fractures that I shall speak.

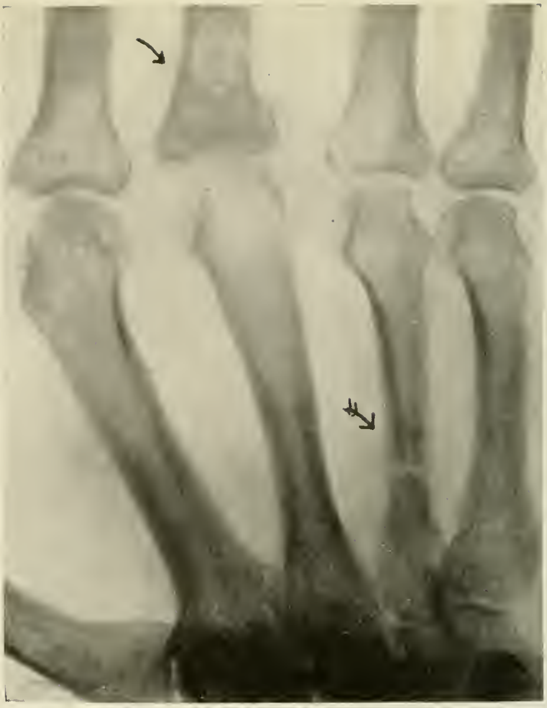

Fig. 1. Cheever (a). Fracture seventh metacarpal shaft with fracture dislocation of proximal end of a phalanx.

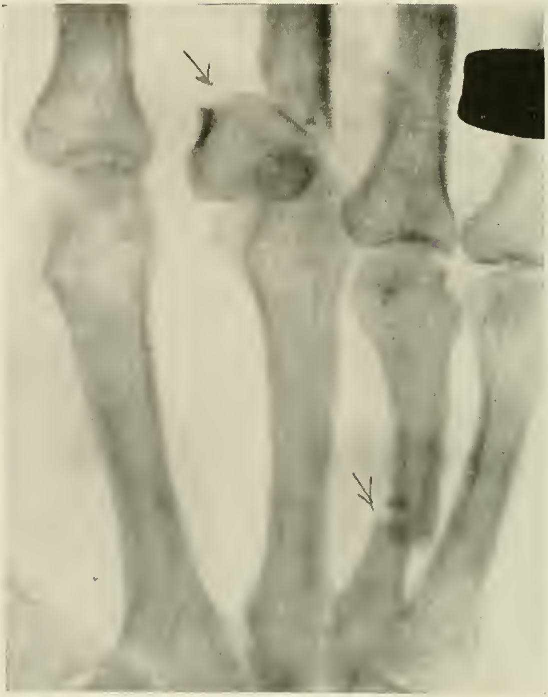

Fig. 2. Cheever (b). Fracture seventh metacarpal shaft with fracture dislocation of proximal end of a phalanx. Complete reduction by incision following two previous failures of closed method.

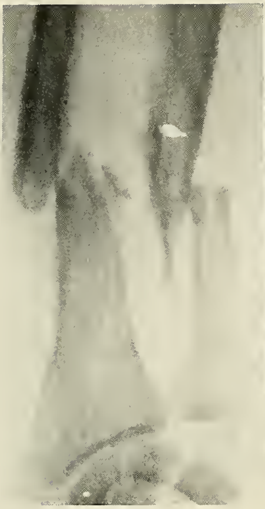

Fig. 3.

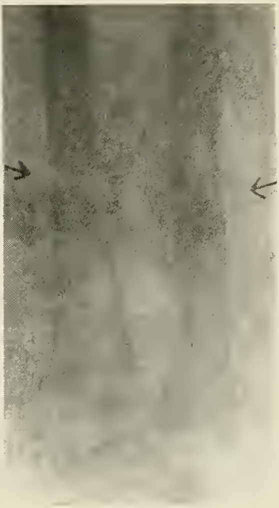

Fig. 4.

Fig. 3. Ayash (a). Fracture both bones of forearm (several weeks old). Before operation.

Fig. 4. Ayash (b). Fracture both bones of forearm (several weeks old) after reduction by open method.

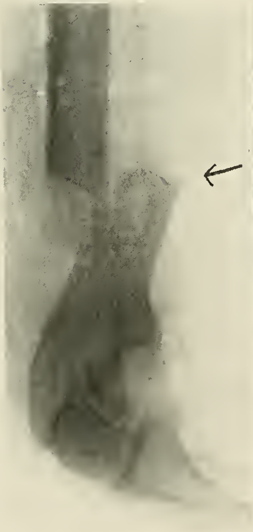

Fig. 5.

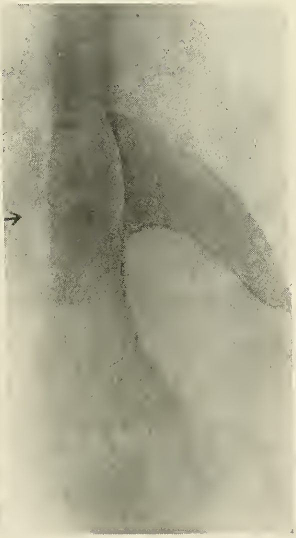

Fig. 6.

Fig. 5. Ayash. (a). Fracture humerus lower one-third. Before operation.

Fig. 6. Ayash (b). Fracture humerus lower one-third after reduction by open method. Plaster dressing.

This small group should, I believe, as a routine, be subjected to an open incision and an anatomical reduction of the fragments. Aside from the return to proper alignment, there always should be considered the question of joint strain, as is strikingly seen in orthopedic surgery more than in general surgery. The general surgeon treats his fracture of the femur and gets union and often never sees the patient again. Years after, an orthopedist finds the patient with scoliosis resulting from a short leg. A shortening of one-half to three-quarters inch in a growing child causes joint strain, resulting in the development of structural deformities. Nevertheless, the surgeon considers one-half inch shortening a good result. Personally, I have reached the stage where I subject all fractures of the femur, except in the infant, to reduction by the open method. There has always been the dread of introducing sepsis in the open fracture wound. I can combat this point only by calling attention to the parallel reluctance of the surgeon to open the knee-joint. It has been only within the last ten to fifteen years that fractures of the patella have been subjected to operative interference as a routine, yet it has been well recognized that in order to get a true bony union in patella fractures not stellate in character, operative interference must be undertaken.

Up to the time Mr. Lane began insistently to champion the open treatment and the use of plates, strong prejudice against the open treatment of fractures existed. This was justified partly by results and partly by tradition. Strict asepsis and non-traumatic technique became recognized as all-important. A surgeon thus well founded has the moral right to treat any fracture by the open method and does not thereby add to the existing dangers. The advent of the open method may, however, bring many disastrous results unless proper asepsis has been carried out. With asepsis we can open safely a fracture and skillfully reduce it with less damage to the surrounding parts than by manipulation.

Undoubtedly, this is the greatest advance that has been made since the advent of bone-plating. I feel strongly that too many metallic splints are being used. Osteomyelitis and irritation from loose screws and metallic material in contact with bone may sooner or later occur. Just as is

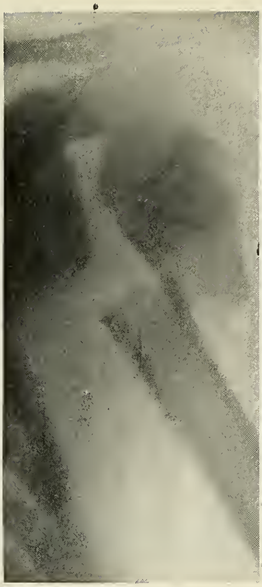
Fig. 7.

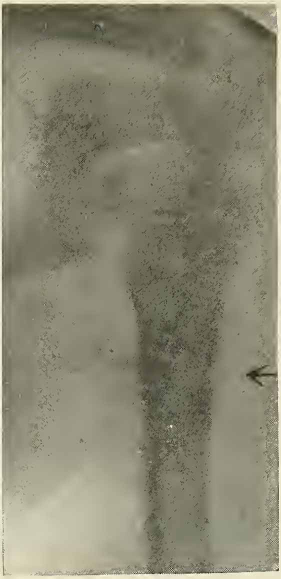
Fig. 8.

Fig. 7. Moses (a). Fracture of upper shaft of humerus. Before operation. Two unsuccessful attempts at reduction by closed method.

Fig. 8. Moses (b). Fracture upper shaft of humerus. After open reduction. Plaster dressing.

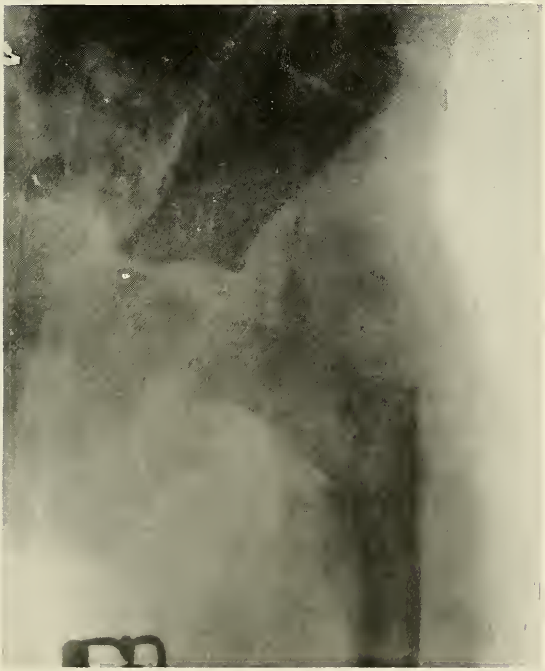
Fig. 9. Subtrochanteric fracture of femur showing traumatic coxa vara, angle of 100 degrees, overriding. Before operation.

seen occasionally in old cases of excision of the knee in which silver wire has been used, discharging sinuses may open ten to fifteen years after the insertion of the wire. Rarely, therefore, I believe, is it necessary to plate—only in exceptional cases where position cannot be held following reduction by manipulation or open method even when held with some absorbable material; in other words, plating is the method of last resort.

Radiograms as routine should be taken before reduction and again through the retentive dressing within a few days after.

The technique developed in this work is, I believe, always individual. An attempt should be made to wall off the skin incision by sterile towels and clamps so that in handling the wound the skin is not touched. I see no reason why the gloved fingers should not be inserted into the wound if the operator is clean, and much muscle separation may be done with a blunt dissector and by the use of the fingers. When the fracture cavity is exposed it is wiped out with sponges and then attention is paid to fragments. If it is a simple transverse fracture, first one end and then the other is pried up into the wound and the ends are brushed off with a sponge. Care is taken not to injure the periosteum or peel it back. After the ends have been cleaned the fragments are placed in alignment, and often the serrations can be made to fit each other so that only the line of fracture is seen. One succeeding in this procedure is at once impressed with the stability of the bone when this anatomical reduction is attained. If there is a tendency to slipping, a notch made with a file will often suffice to hold properly. When there is a slanting fracture, following the above procedure, I am apt to wind with plain catgut. After alignment is obtained, the greatest care should be used to maintain the position of the fragments. This requires trained assistants, or, in femur cases, some form of traction apparatus on which the patient is placed before the operation is started and which will allow the application of plaster before removal, such as the Echol's traction apparatus. Since adopting these methods, I find myself practically abandoning the use of a bone-plate, and the results, not only as regards alignment and position, but also as regards union and function, justify the extra labor and care required by this technique.

It might be well to state here that I remove all bone-plates which I have had to use, in three months' time, and hence have avoided all the unpleasant after-results sometimes seen.

The important point in the treatment of fractures is the return to anatomical alignment. Such return when not complicated by grave risks is always indicated. Union seems to occur more quickly and there is notably less callus formation by this open method.

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ASTRAGALECTOMY (WHITMAN OPERATION) IN INFANTILE PARALYSIS *

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It is not my object to discuss more than in a general way the various operative procedures in the paralyzed foot, but rather to emphasize the value of an operation which has stood the test of time; and unlike tendon transplantation, silk ligaments, etc., has been found practical, efficient and permanent in combating the instability so frequently seen in the paralyzed foot. It seems to the writer that except for one or two possible conditions in the paralyzed foot, transplantation should be discarded in favor of a procedure giving permanent results in the hands of the surgeon. As one compares the results in a series of cases some years after operation, it seems quite remarkable that transplantation of tendons and the use of silk ligaments still persist.

Infantile paralysis most frequently leaves its mark in the muscles of the foot where varying degrees of paralysis persist from a mild weakness of one group or a paralysis of one group to a total paralysis of the entire muscle strength below the knee. The extent of the disability, however, only rarely coincides with the extent of the paralysis.

Weakness, instability of the foot and deformities follow paralysis of one group as frequently as they follow paralysis of all the muscles. It is the failure to recognize this fact that tempts the surgeon to use such insufficient means as transplantation and silk ligaments in order to combat deformity in those cases with slight loss of muscle power. The normal foot is balanced by muscles working in perfect coordination, assisted by ligaments which check extremes of motion. To expect sufficient restoration of balance following transplantation is illogical from a mechanical and physiologic point of view, and in the experience of the writer not based on careful and prolonged clinical observation.

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* Read before the Section on Orthopedic Surgery at the Sixty-Seventh Annual Session of the American Medical Association, Detroit, June, 1916.

Our first duty, of course, is to foresee and prevent structural deformity, thereby favoring regeneration and recovery of power.

If this recovery does not take place, then we arrive at the point where operative interference must be considered or the patient condemned to a brace for permanent support. Here the question arises as to the class of cases in which surgical interference is indicated. We must all believe that operative interference should be delayed as long as there is a possibility of a return of power, e. g., about one and a half to two years following the initial attack. In children, in whom deformity may usually be prevented, my experience leads me to wait longer if the age of 6 or 7 has not been reached. In the presence of deformity not easily correctable by manipulation, this age limit may be lowered a year to hasten good locomotion.

What operation shall we choose? During the past six years I have used astragalectomy as devised by Dr. Royal Whitman[1] in almost all of the deficiencies following infantile paralysis affecting the leg. Altogether my series comprises 135 cases, a sufficient number to warrant the formation of definite opinions concerning its value as an operation. In short, I may state that it has come to replace the commoner operations of transplantation, silk ligaments and allied operations. Astragalectomy gives stability, which is not in my experience obtained by the other procedures, and in addition preserves sufficient motion for good function of the ankle. Arthrodesis when successful stiffens the joint and an awkward gait results.

Age.—Astragalectomy can be done at any age following a period of two years after the original paralysis, but if possible should be reserved until the child is 6 or 8 years old. If, however, deformity is not being prevented by apparatus and if the limp is more than the extent of the paralysis warrants, then I should not wait for this age; for atrophy and shortening go hand in hand with the severity of the deformity and the limp, not with the extent of the paralysis. In the period between 6 and 16 years of age the most satisfactory results are obtainable. We have done the operation later but find that more sensitiveness and pain are liable to follow, and the results, in spite of good stability, motion and a good posture, are not quite as satisfactory as when done early.

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[1] Whitman: Am. Jour. Med. Sc., 1901, **122**, 593; Am. Jour. Orthop. Surg., 1910-1911, **13**, 137; Am. Surg., 1911, **54**, 860.

Indications.—The conditions in the foot for which this operation may be done with benefit are many. Probably the most striking results follow its use in the deformity of calcaneovalgus, for which it was originally planned (Fig. 1). Here with the shifting of the tibial weight forward, and the transplantation of the peronei into the Achilles, a most striking functional result is obtained. But its use cannot be limited to this alone. It gives excellent and standard results in all foot conditions — even where only one muscle is paralyzed.

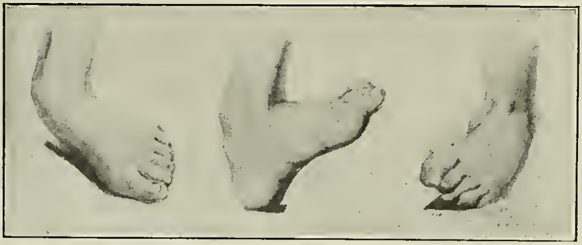

Fig. 1.—Three of the more common deformities in the partly paralyzed foot.

Operative Technic (Figs. 2-10).—Here as in other joint operations the asepsis should be guarded carefully and manipulation should be gentle. A curved or L-shaped incision is made around the external malleolus, tending forward over the head of the astragalus. The upper flap is then dissected upward, exposing the tendons of the peroneus longus and brevis, which are then dissected free and severed just at the fibular tip. The ends are caught in No. 2 catgut sutures and retracted.

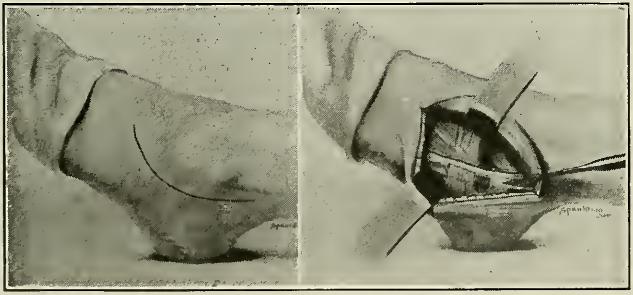

Fig. 2.—Astragalectomy — the Whitman operation: On left, line of incision. On right, tendon of peroneus longus exposed; tendon of peroneus brevis being exposed.

An incision is then made through the external ligaments around the astragalus, using especial care about the head of the astragalus. The foot is strongly inverted. Then by placing a blunt dissector under the neck of the astragalus, the bone is pried out of position head first, and removed. At once the ease of displacing the foot backward will be noticed, but in order to insure a good joint a certain amount of modeling must be done.

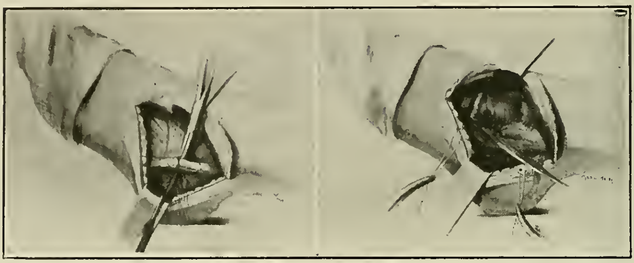

Fig. 3.—Astragalectomy — the Whitman operation: On left, peroneal tendons sutured and divided. On right, external lateral ligament divided: tibio-astragaloid ligament divided; interosseus and external talocalcaneal ligaments being divided.

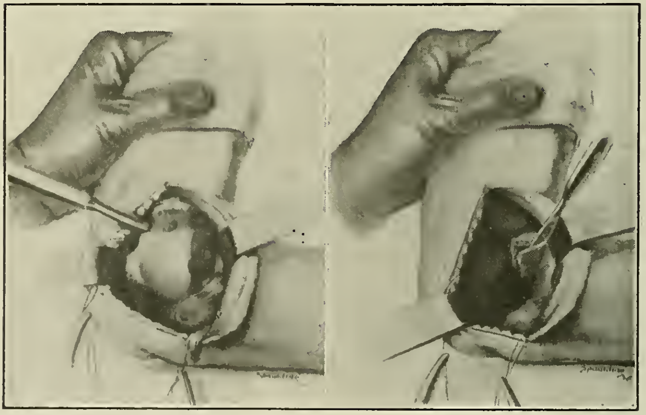

Fig. 4.—Astragalectomy — the Whitman operation: On left, dislocation of astragalus by strong inversion of foot. Note heavy dissector under neck by which astragalus is pried loose head first. On right, widening tibia-fibular articulation by removal of thin slice of cartilage from internal malleolus.

The internal lateral ligament is dissected upward from the internal malleolus; if necessary, a strip of cartilage is removed from both tips to span the scaphoid and cuboid; a small piece is excised from the side of the scaphoid and cuboid to form pockets for the malleoli. The foot is then displaced backward and held carefully in this position to insure the proper relations in the new joint. A moderate equinovalgus gives stability while holding. The peronei are disposed of by suture to the Achilles tendon, by tendon fixation or by resuture to the distal ends of the tendons of the peronei, as indicated in the given case. The skin is closed with catgut and plaster applied from the

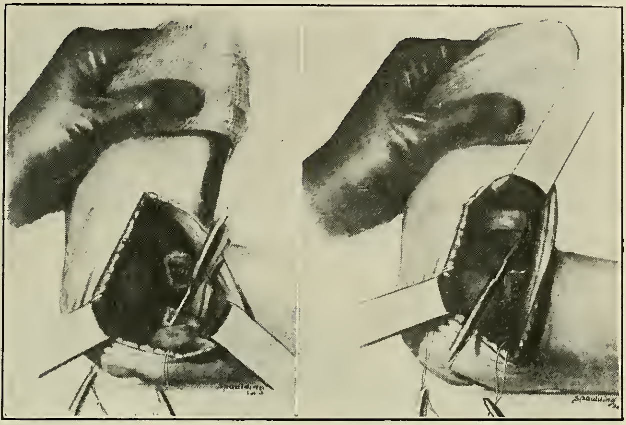

Fig. 5.—Astragalectomy — the Whitman operation: On left, widening the tibia-fibula articulation by removal of thin slice of cartilage from one or both; the internal lateral ligament has been dissected up to sharpen the malleolus. On right, the new articulation for internal malleolus. Note removal of inner one fourth to one sixth from inner side of scaphoid, thus forming pocket for sharpened internal malleolus.

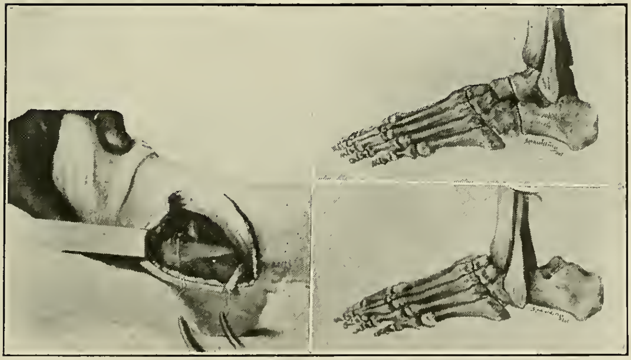

Fig. 6.—Astragalectomy — the Whitman operation: On left, the external malleolus rests in a similar socket over calcaneocuboid joint. Note backward displacement of foot, and fibula carried well forward. On right, above, normal relation of tarsal bones; below, relations following the properly done astragalectomy.

toes to midthigh with the knee flexed and the foot in equinovalgus. The leg is kept elevated for a period of ten days, after which crutches may be used. The first change of cast takes place in three or four weeks, at which time the equinus is corrected to a right angle in cases of quadriceps paralysis or left in 5 to 8 degrees equinus where the quadriceps is present. Valgus should persist throughout the treatment.

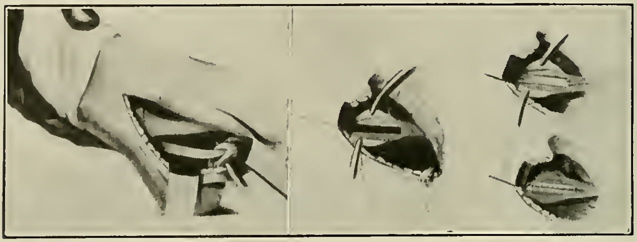

Fig. 7.—Astragalectomy — the Whitman operation: Disposition of tendons of peronei into the Achilles tendon and resuture, and tendon fixation (Galli operation).

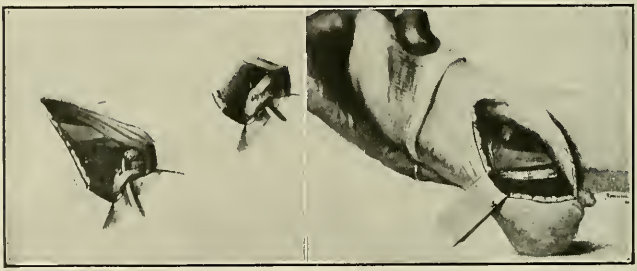

Fig. 8.—Astragalectomy — the Whitman operation: Disposition of tendons of peronei, into Achilles tendon, and resuture of ends.

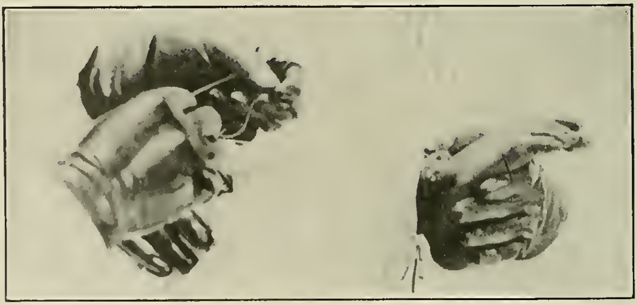

Fig. 9.—Astragalectomy — the Whitman operation: Note the posterior displacement and the position in which the foot is being held during suture and the application of plaster with the knee flexed and the foot in slight equinovalgus.

A leather shoe (Fig. 11) is then put over the plaster and the child allowed to walk, changing the plaster as necessary for five to six months. Following its removal a shoe with a lift on the outer side of the sole is used. A one-half or three-quarter inch cork lift under the heel will compensate for the shortening of the leg and improve the gait. Circulation improves rapidly with the return of good function and loss of growth ceases, the paralyzed leg beginning to grow at a rate equal to that of the well side.

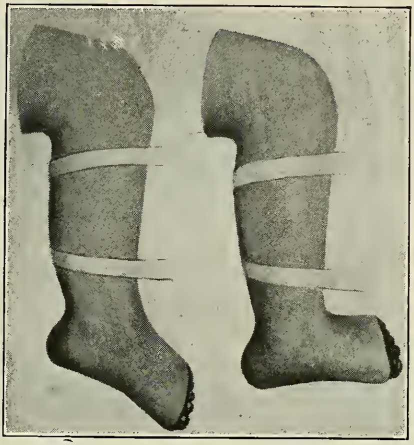

Fig. 10.—Astragalectomy — the Whitman operation: In plaster, following operation.

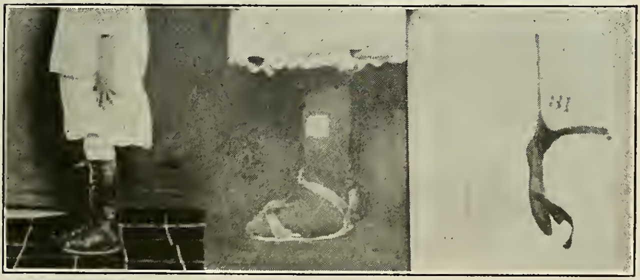

Fig. 11.—Shoes to be worn after Whitman astragalectomy.

Conclusion.—The results obtained with astragalectomy have led me to discard, except in the rare cases, all other procedures.

Various methods for remedying the condition have been devised. Amputation of the foot in cases of severe deformity is advocated by Watson.[2] I know of no other report on this operation. Lange's silk ligaments are advocated by many authors, among whom are Allison,[3] Bradford,[4] Barton and Plummer,[5] and Lovett.[6] Rich[7] says that they are of use in joints

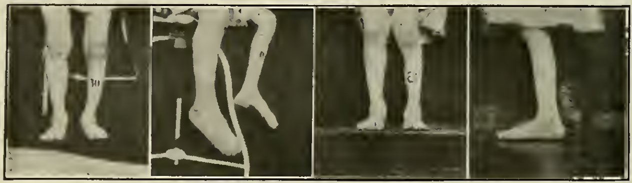

Fig. 12.—Infantile paralysis, valgus deformity: From left to right, anterior view before operation, lateral view before operation, anterior view twenty months after astragalectomy, and lateral view twenty-two months after astragalectomy.

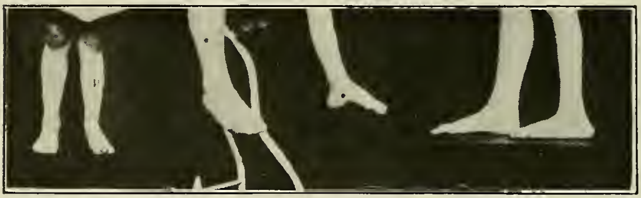

Fig. 13.—Infantile paralysis, calcaneovalgus deformity: Anterior view before operation, lateral view before operation, and lateral view twenty months after astragalectomy (Whitman).

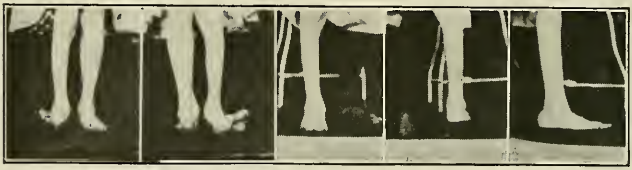

Fig. 14. — Infantile paralysis, calcaneovalgus deformity, operation, May, 1912: Anterior view before operation, posterior view before operation, anterior view six months after astragalectomy (Whitman), posterior view six months after operation, and lateral view six months after operation.

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[2] Watson: Brit. Jour. Surg., 1914-1915, p. 390.

[3] Allison: Am. Jour. Orthop. Surg., 1912-1913, p. 519.

[4] Bradford and Soulter: Boston Med. and Surg. Jour., 1907, **157**, 655.

[5] Barton and Plummer: Am. Jour. Orthop. Surg., 1912-1913, p. 499.

[6] Lovett: Am. Jour. Orthop. Surg., 1905, **12**, 405.

[7] Rich, E. A.: Limitations of Lange's Silk Ligaments in Paralytic Surgery and Substitutes Therefor, The Journal A. M. A., Nov. 1, 1913, p. 1597.

where there is no external irritation, as there is in the ankles from shoes. Here he advocates capsule tucking. Nerve grafting is advocated by Spitzi and others. The general opinion has been summed up by Feiss,[8] who says there is no experimental evidence to justify its use in paralytic cases. Tendon transplantation has its chief advocate in Vulpius.[9] Soule[10] advocates arthrodesis of the astragaloscaphoid joint, with the use of a bone peg to aid ankylosis.

The operation of astragalectomy was first performed in 1842 by Lund[11] of London for the correction of a very severe talipes, and its use has since been reported by numerous authors, usually in traumatic and infectious cases. Willens[12] reports in 1911 its use in cases of clubfoot in an operation devised by him. Peraire[13] used it with goods results in a case of traumatic paralytic equinovarus. In none of these was the foot displaced backward. Its use in paralytic talipes was first advocated by Dr. Whitman in 1901. The operation briefly consists of the enucleation of the astragalus, fibro-arthrodesis of the joint, transplantation of the tendons, and the backward dislocation of the foot. The cases in which it is serviceable have since been much extended by Whitman. Favorable results from the operation have been reported by Dane and Townsend[14] in a series of cases from the Childrens' Hospital, Boston, and also by Lord[15] and others.

The operation has been modified by Robert Jones,[16] who divides it into a two part procedure. His method is not much used in this country. Tubby[17] modifies the operation by using Lange's silk ligaments to strengthen the Achilles tendon after division.

Tendon fixation separately or as an adjunct to astragalectomy has been used by the author in several of his later cases with good results.

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[8] Feiss: Rev. neurol. and psychiat., **11**, 307.

[9] Vulpius: Am. Jour. Orthop. Surg., 1912-1913, **10**, 272.

[10] Soule: Tr. Am. Orthop. Assn., Philadelphia, 1914.

[11] Lund: London, 1872.

[12] Willens: Brit. Med. Jour., **2**, 984.

[13] Peraire: Paris chir., 1912, **4**, 294.

[14] Dane and Townsend: Am. Jour. Orthop. Surg., 1904, **11**, 38.

[15] Lord, J. L.: The Whitman Operation for Talipes Calcaneus Paralyticus, The Journal A. M. A., Oct. 11, 1913, p. 1374.

[16] Jones, Robert: Lancet, London, 1914. **1**, 1786.

[17] Tubby: Clin. Jour., 1912-1913, **40**, 163.

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August, 1916, pages 147-152

SEPARATION OF THE LOWER FEMORAL EPIPHYSIS

WITH REPORT OF TWO CASES

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SEPARATION of the lower femoral epiphysis is of rare occurrence. Radical treatment of the condition is so necessary that the following cases are reported for the interest they may add to the present literature on the subject.

This type of fracture usually occurs from direct violence, such as the catching of a leg in the spokes of a revolving wheel. The deformity is usually a displacement of the epiphysis backward into the popliteal space, the lower end of the shaft projecting its sharp edge forward above the patella. Conservative treatment of such displacement by the inclined plane, or other traction and splinting methods are useless. Closed reduction under an anæsthetic is accompanied by dangers, injury to the popliteal nerves and vessels, and the improbability of obtaining complete reduction. In a joint which is as important as the knee-joint a slight deformity may result in permanent injury to the epiphysis followed in due time by irregular growth and increasing deformity. Also blood in the joint filling the quadriceps pouch as well, if allowed to organize with the knee kept at rest will spell disaster to the return of joint motion. The importance of removal of blood-clot from the knee-joint cannot be overestimated, for many stiff knees, not the result of sepsis, are the direct result of the obliteration of the joint in the process of the organization of blood-clot. Hence the use of a tourniquet in all knee-joint surgery is, in the opinion of the writer, very necessary.

The open reduction of this deformity not only is simple, but should always succeed in giving proper alignment and a clean, blood-free joint. Hence it is always best to resort to operation in this and in similar injuries.

The risk of operation should be minimized of course by the strictest attention to the details of asepsis and by hæmostasis; both should be as perfect as may be obtained. It may seem superfluous to emphasize such detail, but it is only by extreme care that the many pitfalls attending joint surgery may be avoided, and only by such care that good as well as constant results may be achieved.

The details of operative procedure are as follows: A tourniquet is applied. A lateral incision, usually on the inner side, is carried down to the seat of fracture by blunt dissection, and the accumulated blood-clot thoroughly washed out. With a blunt dissector or other heavy instrument, the lower fragment is pried into place, usually without much resistance and usually with complete anatomical reduction of fragments. The well-fitted serrations give to the reduction a valued stability and as well, insure the slightest possible injury to the epiphysis. The soft parts are closed with catgut and the skin with silkworm-gut. A tight bandage is applied over the dressing and the tourniquet is removed. Plaster is then applied from the groin to the ankle. At the end of one week, the plaster is split and a few degrees of motion made without removal of the leg from posterior shell. This process is repeated gently each day. The plaster is taken off after ten days, and from this time on there may be expected an uneventful convalescence. Note especially Case 1 and the photographs of the end-result. Case 1 was operated on 18 hours after the accident. Case 2 was not operated on for three weeks, which accounts for the knee allowing only 100 degrees motion in flexion.

Case 1. George M., age 9; referred by Dr. Francis McMurray of Fitchburg. The patient was a healthy boy with the exception of enlarged tonsils and adenoids for which he was operated upon April 10, 1912. On Friday, May 17, 1912, while stealing a ride on the back of a baker's wagon, his right leg was caught in the spokes of the rear wheel. His screams attracted the attention of a passerby who called to the driver, and the cart was brought to a stop. The boy complained of much pain in the region of the right knee. There was much swelling and evident deformity at the knee. The radiogram showed an epiphyseal separation with the displacement backward, inward, and slightly upward so that it came to lie against the posterior aspect of the shaft (Fig. 1).

Operation, May 18, 1912, under ether anæsthesia. An incision about three inches long was made on the inner side over the epiphyseal line down to the fracture. The blood-clot was washed out with salt solution, and by the use of a blunt dissector the fractured epiphysis was pried into place so that the serrated edges fitted perfectly and there was no deformity at any point. The wound was sewed up in the usual manner, and dry dressing and plaster from the ankle to the groin applied with the knee at 180° (Fig. 2). On May 27, the stitches were removed. The wound healed by first intention. On June 3, the patient sat up in a chair. On June 11, he was discharged from the hospital. The plaster was removed entirely at the end of two weeks. His highest temperature was 100.8°. Convalescence was uneventful; motion was regained rapidly. The end-result is perfect (Figs. 3 and 4).

CASE 2. A. C., age 17; referred by Dr. S. M. Gordon, Fall River. The patient had an injury in one of the Fall River mills, March 6, 1911, in which he sustained a compound fracture of the left leg, crushing the ankle-joint. Both bones were fractured low in the tibia through the tibial condyle. The right foot was contused and lacerated. The right lower femoral epiphysis was displaced backward. On April 10, 1911, the left foot was amputated by Dr. Gordon. On May 13, 1911, the patient was seen in consultation with Dr. Gordon and open operation advised for the reduction of the displaced epiphysis (Fig. 7). The epiphysis was separated and dislocated backward into the popliteal space. The shaft projected forward.

Operation, May 13, 1911, under ether anæsthesia. An incision was made on the inner side of the knee at the point of fracture and the epiphysis pried in place by means of a blunt dissector. A cast was applied. Recovery was uneventful. On June 2, the cast was removed. On October 16, he was discharged from the hospital, wearing a caliper brace. On March 8, 1912, he was admitted to the hospital for correction of slight knock-knee, and a supracondylar osteotomy was done. On April 13, there was good union from the osteotomy and alignment was good. On May 4 the patient was up and about, walking with brace.

Bauer's case was that of a 14 year old boy who had developed a deformity from an unrecognized separation of the epiphysis seven years before. There was present genu valgum and marked shortening.

Binney and Lund advise in the average case of epiphyseal separation open reduction with a nail through the condyle, although they had used this treatment in only one of the cases given in their report. In the two cases cited, one of backward displacement, the other of

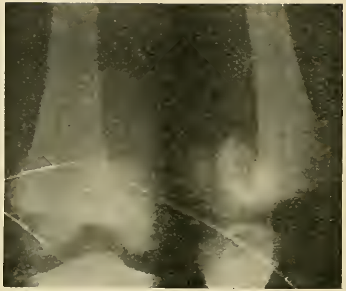

Fig. 1. Radiogram of Case 1 before operation.

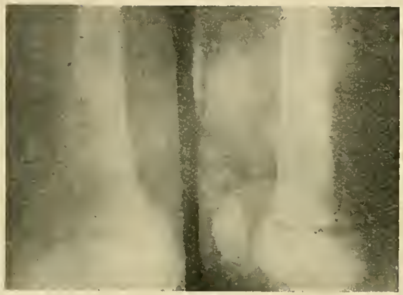

Fig. 2. Radiogram of Case 1 after operation.

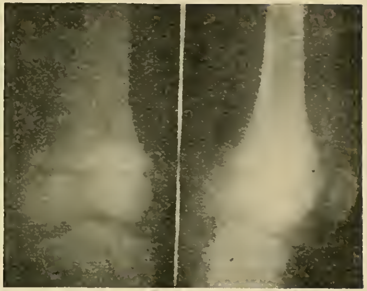

Fig. 3. Radiogram one month after operation, showing end-result.

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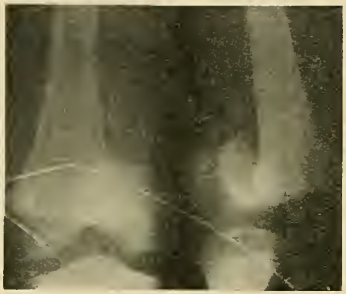


Fig. 1. Radiogram of Case 1 before operation.

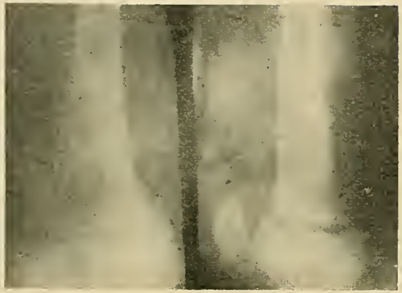


Fig. 2. Radiogram of Case 1 after operation.

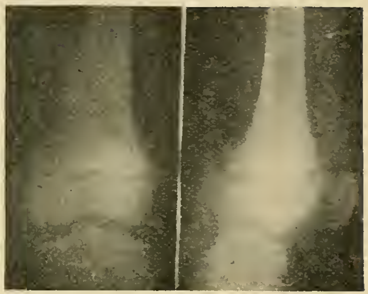


Fig. 3. Radiogram one month after operation, showing end-result.

backward and outward displacement, reduction by manipulation was found sufficient.

Cotton advises reduction by traction on the leg, with the knees bent with direct pressure on the protruding fragment.

Coural's case was related by Fontelli, and the specimen which was in his possession described by Delpech. The child was without treatment for four days. At the end of that time routine treatment failed to reduce the deformity, and amputation was refused although gangrene had developed. Twenty-three days later the foot separated from the leg, and finally Coural amputated four inches above the condyles. The epiphysis was found separated from the shaft in the middle of the cartilaginous layer.

Dukes reported a case of a boy who received a blow on the outer side of the right leg while his legs were abducted in full extension. The epiphyses was felt as a prominence in the median line. Suspension with pulleys was unsuccessful. A straight "long outside" splint with perineal extenders was better. Finally a pressure pad was added, the perineal band removed and extension employed.

In the case reported by Fischer and Hirschfeld, the boy was caught in the belt of a threshing machine, resulting in the separation of the lower epiphysis of the right femur, the upper epiphysis of the left tibia and both epiphyses of the left fibula. Amputation through the upper part of the left thigh was later necessary. The right leg was first put on a double inclined plane and icebags applied. In a few days, the part was put up in plaster. Recovery was slow.

Halderman's case was of a mulatto with tuberculosis. Conservative treatment was undertaken although the dorsalis pedis was pulseless. Replacement under narcosis was attempted. Gangrene set in, requiring secondary amputation. On dissection considerable destruction of the soft parts was found and the nerve caught between the fractured ends of the bone. The patient recovered from the operation but died thirty days later from pyæmia.

Hartwell reported one case in which the line of fracture was oblique from a point about 2 inches above the epiphysis on the inner side of the femur, outward and downward to the epiphyseal line at the center of the bone. An osteotomy was performed through the line of fracture and the fragments were brought into apposition by traction and manipulation with bone hooks. The wound was closed with drainage and the leg put up in plaster.

Hilton reports a case of a boy of 18 who fell while carrying a hod of coal. The deformity was reduced three times under narcosis; the first time by extension, the other times by extension and pressure on the shaft.

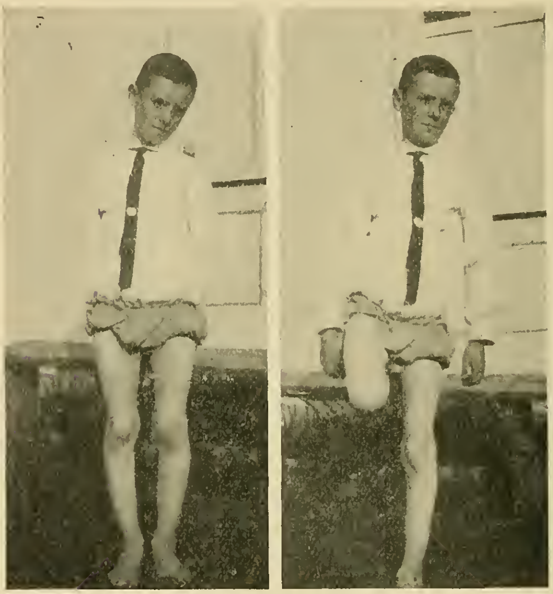


Fig. 4. Photographs showing extension and flexion after union in Case 1.

After the first recurrence, a posterior splint was applied. After the second, posterior and lateral splints, and the leg was elevated with the thigh flexed. Firm union resulted in seven weeks.

In Jouon's case, the leg was severely twisted and almost torn off above the knee. The knee-joint was opened behind and the nerve and bloodvessels torn. The diaphysis protruded 5 cm.

Macdougall reports a case seen by him for the first time a month after the injury. The surgeon who had attended the boy at the backward and outward displacement, reduction by manipulation was found sufficient.

Cotton advises reduction by traction on the leg, with the knees bent with direct pressure on the protruding fragment.

Coural's case was related by Fontelli, and the specimen which was in his possession described by Delpech. The child was without treatment for four days. At the end of that time routine treatment failed to reduce the deformity, and amputation was refused although gangrene had developed. Twenty-three days later the foot separated from the leg, and finally Coural amputated four inches above the condyles. The epiphysis was found separated from the shaft in the middle of the cartilaginous layer.

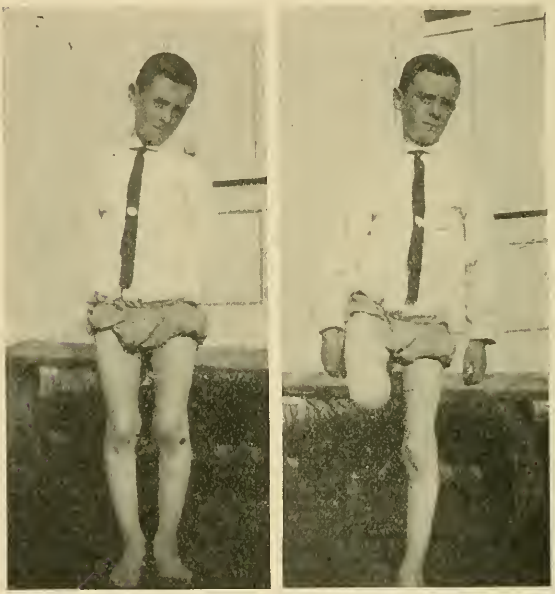
Dukes reported a case of a boy who received a blow on the outer side of the right leg while his legs were abducted in full extension. The epiphyses was felt as a prominence in the median line. Suspension with pulleys was unsuccessful. A straight "long outside" splint with perineal extenders was better. Finally a pressure pad was added, the perineal band removed and extension employed.

In the case reported by Fischer and Hirschfeld, the boy was caught in the belt of a threshing machine, resulting in the separation of the lower epiphysis of the right femur, the upper epiphysis of the left tibia and both epiphyses of the left fibula. Amputation through the upper part of the left thigh was later necessary. The right leg was first put on a double inclined plane and icebags applied. In a few days, the part was put up in plaster. Recovery was slow.

Halderman's case was of a mulatto with tuberculosis. Conservative treatment was undertaken although the dorsalis pedis was pulseless. Replacement under narcosis was attempted. Gangrene set in, requiring secondary amputation. On dissection considerable destruction of the soft parts was found and the nerve caught between the fractured ends of the bone. The patient recovered from the operation but died thirty days later from pyæmia.

Hartwell reported one case in which the line of fracture was oblique from a point about 2 inches above the epiphysis on the inner side of the femur, outward and downward to the epiphyseal line at the center of the bone. An osteotomy was performed through the line of fracture and the fragments were brought into apposition by traction and manipulation with bone hooks. The wound was closed with drainage and the leg put up in plaster.

Hilton reports a case of a boy of 18 who fell while carrying a hod of coal. The deformity was reduced three times under narcosis; the first time by extension, the other times by extension and pressure on the shaft. After the first recurrence, a posterior splint was applied. After the second, posterior and lateral splints, and the leg was elevated with the thigh flexed. Firm union resulted in seven weeks.



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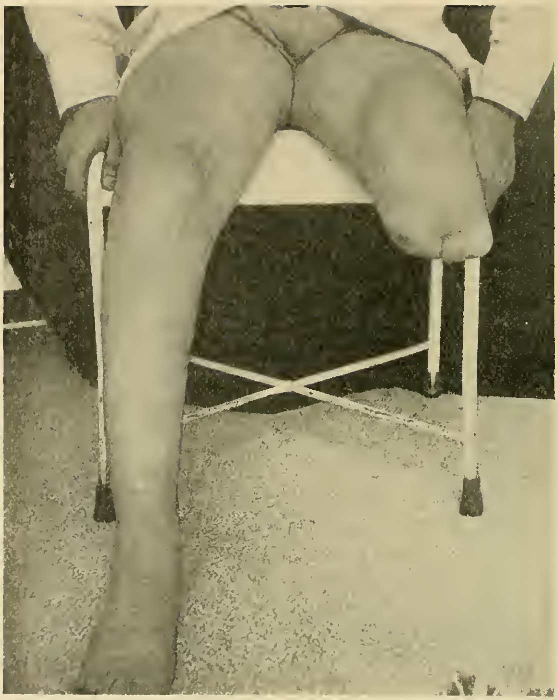
Macdougall reports a case seen by him for the first time a month after the injury. The surgeon who had attended the boy at the time of the trauma was unable to reduce the lower fragment which was drawn very acutely backward so that the integument was drawn taut. There was not much displacement of the shaft. The limb was put up finally in a splint and fixed at a not very acute angle. When Macdougall saw the child, the limb was shrunken and the skin over the dislocated fragment ulcerated and there was no attempt at union. After amputation, the vessels were found uninjured.

In Packard's case, examination under ether showed that although there had been great bruising and laceration of the soft parts, the vessels were not torn but were sharply stretched and the blood in the artery coagulated. Reduction was found impossible without resection and as this was thought inadvisable amputation was performed.

In simple cases Poland advised reduction under anæsthetics, by manipulation where this is possible. Where there is danger of injury to the soft parts, or where muscle or periosteum have become interposed between the fractured ends, or when a correct position cannot be maintained, he advocated open operation and suturing of the fragments. It may sometimes be necessary to remove a portion of the diaphyseal end. He puts the limb up on a double inclined plane. Amputation, he believes, is preferable to excision of the epiphysis, but should be performed only after the gravest injury to the soft parts, for gangrene, suppuration, or severe after-results.

Prochnow gives a case caused by falling on a curbstone, striking the knee violently. The knee was displaced backward and outward. The patella was drawn toward the outside. The limb was put up in partial flexion on a double inclined plane, which did not entirely overcome the deformity, causing necrosis later of the skin, exposing the bone for 1 to 2 cm. The exposed bone necrosed with a moderate amount of suppuration.

In Richet's case, the leg was caught in a strap of machinery and twisted violently so that it was bent upon the thigh to a right angle. The end of the diaphysis, covered with epiphyseal cartilage projected through a large wound on the outer aspect of the thigh. The joint was intact and the femoral con-



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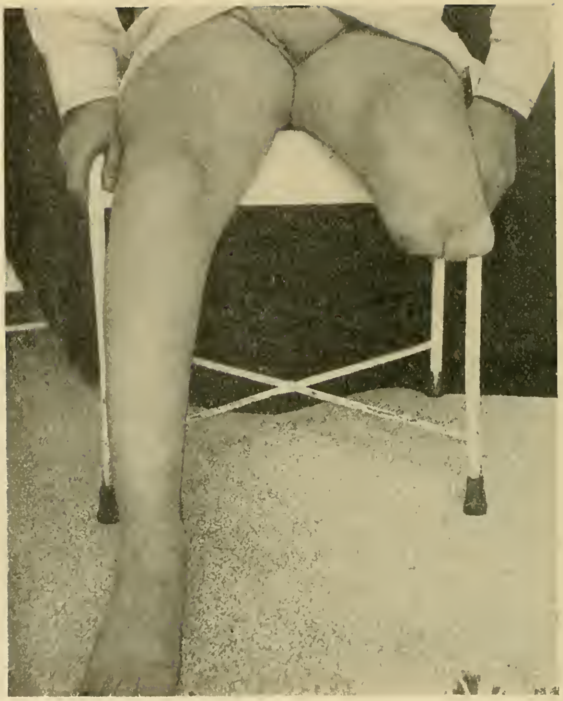

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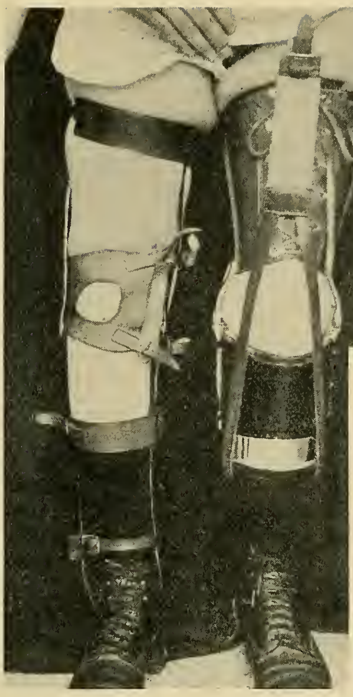


Fig. 6.

Fig. 7.

Fig. 6. Photograph showing brace in Case 2.
Fig. 7. Radiogram of Case 2 before operation.

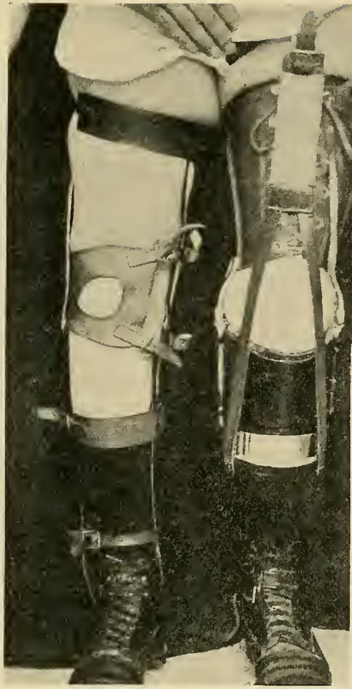
dyles and the patella remained in normal relations to the tibia. Reduction without an anæsthetic was followed by delirium, elevation of temperature, etc. Death from pyæmia occurred on the sixteenth day. During the convulsions, the epiphysis was displaced backward.

Robert's case was complicated by injury to the external popliteal nerve, resulting in toe-drop. This condition ultimately disappeared without operation.

In the case of the specimen at St. George's Hospital Museum, there were injuries to soft parts and separation of the epiphysis of the tibia and fibula. Amputation was done. Death from pyæmia resulted in 14 days.

TABLE OF CASES

No.	Author	Age	Cause	Type of Injury	Treatment	Result	Reference
1	Bauer	7	Blow on knee	Epiphysis of left knee displaced backward and outward	Resection of knee	Recovery with good function	Cited by Monsehr. Inaugural Dissertation, Greifswald, 1897, 20; cited by Hilgenreiner, loc. cit., p. 180.
2	Binney and Lund	11	Leg caught in spokes of wheel	Displacement of epiphysis outward and backward	Ether plaster	Good immediate result	Boston City Hosp. M. & S. Rep., 1913.
3	Binney and Lund	10	Fall	Slight posterior displacement of epiphysis	Plaster	Good immediate result	Ibid.
4	Roughton	5	Leg caught in spokes of wheel	Compound separation of epiphysis with rotation backward	Resection of femur	One-half inch shortening and slight flexion; partial ankylosis	Lancet, Lond., 1900, i, 233.
5	Cottam	6¾	Caught in spokes of wheel	Compound fracture. Diaphysis displaced outward, epiphysis backward	Resection and wiring	Boy became knock-kneed	Med. Rec., N. Y., 1905, lxvii, 487.
6	Cotton				Manipulation		Dislocation and Joint Fractures, 1911, p. 505.
7	Cotton				Manipulation		Ibid.
8	Coural	11	Fall forward with knee in hole	Diaphysis dislocated into popliteal space. Epiphysis tilted backward	Secondary amputation	Recovery	Cited by Delpech. Chir. Clin., 1823, i, 252; cited by Poland, loc. cit., 732.
9	Dukes	18	Struck on outer side of knee	Epiphysis slightly rotated backward	Pressure pad over epiphysis	Union in 6 weeks without shortening	Brit. M. J., 1874, p. 402.
10	Fenwick		Fall	Epiphysis displaced backward and drawn up in front of the diaphysis			Proc. Roy. Soc. Med., Lond., 1911, v, Electro-Therap. Sect., p. 156.
11	Fischer and Hirschfeld	17	Caught in belt	Diaphysis slightly displaced forward. Epiphysis rotated so that the internal condyle ascended somewhat forward and the external condyle descended backward		Fracture consolidated with some displacement and rotation of the epiphysis	Berl. klin. Wchnschr., 1865, ii, 93.



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12	Haldermann	18	Blow on front and inner side of thigh	Epiphysis tilted backward and overlapped by the shaft on its posterior and outer aspect	Double inclined plane. Secondary amputation	Death from pyæmia	Med. Rec., N. Y., 1882, xxi, 600.
13	Hartwell	16	Fall from horse	Oblique fracture with lower fragment displaced backward	Osteotomy	Healed in 12 days	Ann. Surg., Phila., 1904, xl, 1022.
14	Hilgenreiner	7½	Forcible reduction of congenital hip	Epiphysis displaced backward	Plaster	Union in 3 weeks	Beitr. z. klin. Chir., Tubing., 1909, lxiii, 102.
15	Hilton	18	Fall with weight on shoulder	Epiphysis displaced backward, diaphysis forward	Reduction	Firm union in 7 weeks with good function	Med. Times & Gaz., 1859, 163; cited by Poland, loc. cit., 765
16	Hutchinson	12	Run over	Compound fracture	Primary amputation		Tr. Path. Soc., 1864, xv, 206.
17	Hutchinson	14		Epiphysis dislocated backward	Primary amputation		Arch. Surg., 1893, iv, 4, 287.
18	Jouon	7	Leg caught in spokes of wheel	Compound fracture. Epiphysis rotated and pulled backward	Primary amputation	Recovery	Rev. d'orth., Par., 1902, iii, 488.
19	Laugier		Fell into hole	Epiphysis displaced backward and drawn up in front of shaft	Secondary amputation	Death	Nouveau dictionaire de médecine et de chirurgie practiques. Paris; 1869, Cuisse, p. 498; cited by Poland, loc. cit., 732.
20	Macdougall	20	Leg caught in endless rope	Very great backward displacement	Splint. Secondary amputation	Recovery	Edinb. M. J., 1890, xxxvi, 825.
21	McDiamid	8	Leg caught in wheel	Epiphysis rotated so that the articular surface looked forward and the detached surface backward	Primary amputation	Recovery	Northern Lancet, Winnepeg, 1891, v, 1.
22	Packard	9	Leg caught in wheel	Compound fracture with shaft protruding backward and epiphysis rotated backward	Primary amputation	Recovery	Med. News, 1891, Mar. 21, 339; cited by Poland, loc. cit., 729.
23	Poland (A)	13	Fell down step	Epiphysis displaced inward and a little backward. Shaft displaced outward	Extension	Union in 7 weeks	Poland, loc. cit., 774.
24	Poland (J)	3½	Fell on hands and knees	Epiphysis displaced backward and inward	Reduction under ether. Plaster	Union slowly with considerable thickening	Poland. Traumatic Separation of the Epiphysis. London: 1898, p. 685.
25	Prochnow	10	Fell on knee	Epiphysis displaced backward and outward	Double inclined plane	Necrosis of skin. Recovery in 8 months	Gyógyászat. Budapest, 1892, Nov., xxxiv, 545; Abstracted Pest. med. chir. Presse, Budapest, 1803, xxix, 389; cited by Poland, loc. cit., 741.

TABLE OF CASES (Continued)

No.	Author	Age	Cause	Type of Injury	Treatment	Result	Reference
26	Reboul	7	Leg caught in spokes of wheel	Epiphysis rotated so that its fractured face looked backward. Diaphysis displayed into popliteal space	Extension. Open reduction. Metallic sutures	Slight genu valgum. No shortening. Movement normal. Function perfect	Ass. franc de chir. Proc., verb. (etc.) Par., 1904, xvii, 617.
27	Reboul	17	Fell from horse	Diaphysis displaced outward and backward. Epiphysis rotated upward and backward	Open reduction. Metallic sutures. Secondary amputation	Recovery	Ibid.
28	Richet	13	Leg caught in strap of machinery	Compound fracture. Diaphysis projected on outside. Secondary displacement of epiphysis backward	Reduction without anæsthetic	Death	L'Union méd., Par., 1876, xxi, 426.
29	Roberts			Displacement of epiphysis into popliteal space	Conservative	Recovery with good function	Ann. Surg., St. Louis, 1896, xxiii, 201.
30	Schmidt	6½	Struck with hammer	Epiphysis displaced backward	Reduction under narcosis	Recovery with good function	Fortschr. a. d. Geb. der Roentgenstrahlen, 1899, iii, 1.
31	Sheppard	15	Leg caught in spokes of wheel	Epiphysis dislocated backward and outward. Diaphysis displaced inward	Immobilized in slight flexion, later extension.	Union in 7 weeks with good function	St. Thomas's Hosp. Rep., 1877, viii, 433; cited by Poland, loc. cit., 767
32	Sheppard	15	Fall	Shaft projected forward	Splint with leg flexed		St. Thomas's Hosp. Rep., 1877, viii 436; cited by Poland, loc. cit., 766.
33	Specimen at St. Georges Hospital No. 56 A	18	Leg caught in cable	Epiphysis displaced backward and outward. Diaphysis displaced inward	Amputation	Death	St. George's Hosp. Mus. Cat., 1866, p. 43; cited by Poland, loc. cit, 721.
34	Sturrock	11	Run over by cab	Epiphysis displaced backward and outward	Flexion	Slight thickening. Perfect function	Edinb. Hosp. Rep., 1894, ii, 598.
35	White			Compound fracture witb end of shaft protruding forward	Resection	Recovery	Cited by Poland, loc. cit., p. 719.
36	Evans			Separation of lower epiphysis of right femur backward			J. Royal Army Corps, Lond., 1914, xxiii, 348 (Article not seen).

Fracture Treatment from the Standpoint of the Orthopedic Surgeon.

BY DR. W. RUSSELL MACAUSLAND.
Surgeon-in-Chief of Orthopedic Surgery at the Carney Hospital.

Mr. Chairman and Gentlemen:

The subject of "Fracture Treatment" is always of great interest to the general practitioner. The advances which have been made in the open methods of certain fractures have brought surgeons to this period in which it may truthfully be said that "The art is long and the judgment difficult." The best function in the shortest period of time is the only measure of the proper application of any principle.

All of us are cognizant of the fact that the larger portion of fractures are better treated by conservative means when the mandates of certain principles are properly carried out, yet we see among these cases many poor functional results attributable to either lack of knowledge of these principles or to lack of care in carrying the treatment out. Function permanently impaired by persisting deformity cannot be influenced by after treatment, no matter how conscientiously persisted in; baking and massage cannot take the place of proper primary treatment, and the selection of proper treatment and the perfect completion of such treatment is becoming more and more important.

From an industrial standpoint insurance companies already are placing these injuries more and more in the hands of surgeons interested in this special subject and are getting thereby more consistent results than when their fractures were treated by whoever happened along. One hospital in a large city is now doing all this class of work for certain companies with a special staff, and in Boston a new, well-equipped hospital is partly given over to the care of these cases. The insurance companies are recognizing from an economic standpoint that judgment in fracture cases must be in competent hands. We, however, are more interested in the subject from the standpoint of the patient, to obtain the best functional results in the shortest period of time.

What is the method to be selected in the individual case? What is the object and reason for selecting this form of treatment? What cases require open incision? What advantage is to be expected with operative interference? What are the dangers connected with operative interference? Should we use bone splinting or plates in these operative cases and what form of retentive apparatus is preferable for immobilization? What is the after treatment? What special fractures require special treatment? These are all questions that we are continually confronted with, all of which have to be answered independently in any given case.

A fracture is a solution of continuity either with or without displacement. Deformity, that is, displacement represents by far the main cause of disability, just as deformity is the important fundamental in other orthopedic conditions, as flat feet, club feet, etc. Deformity, then, representing a distortion from normal should always be corrected.

Immediately you may ask, "Is perfect reduction necessary?" In answer I will say that the more perfect the alignment the more perfect and rapid the return to normal and the better the functional end-result. This is more true, if possible, in fractures near and involving joints, more important as a principle in dealing with the lower than the upper extremity. Furthermore, imperfect alignment means excessive callus, which in itself increases danger of loss of joint motion, for even a shaft fracture may have muscle and fascia adherent to a degree that limits motion, to say nothing of nerve pressure and the dangers from such excessive callus.

Surgically, it is most gratifying to obtain perfect alignment, to find almost no callus externally, and to demonstrate a perfect joint following a near joint fracture. It is for this we should strive. Unfortunately routine treatment of fractures in many of our hospitals is carelessly handled. The surgeon is either too busy or else not interested, leaving them to the uncertain care of an interne. This is wrong. The work should be done by a man desiring to study and spend time in this branch of surgery.

Take, for example, fractures of the hip. Could any more consistently deplorable results be found? It seems to me about time to give up Buck's traction, which does not reduce deformity, sand bags, which do not immobilize, and all other makeshifts which have proven their inefficiency for so long a time.

For the purpose of discussion I shall divide fractures into three groups:

1st. Fracture of the long bone.
2nd. Fracture in and about joints.
3rd. Fracture of the spine.

1st. Fracture of the humerus and shaft of the femur do fairly well under conservative treatment when there is little displacement. Where there is much displacement and when approximation is poor I do not hesitate to etherize and apply severe extension by means of heavy apparatus, such as the Hawley frame, and apply plaster to hold. If this method is not satisfactory, for any reason, then I do not hesitate to operate. Many of these fractures (as will be shown by lantern slides) can be easily placed in absolute anatomical reduction by a simple open incision, the serrations fitting perfectly. In the spiral ones, where approximation is poor, after replacement they may be wound with catgut to hold until some retentive dressings are applied. This form of treatment is especially desirable in certain fractures of the carpal and tarsal shafts, in which perfect alignment can be obtained by open incision and reduction with the help of a blunt dissector.

Non-union of such fractures is usually due to poor approximation or the interference of some fascia or muscle tissue. We have all seen cases of delayed union which later on united. If, however, after a period of four to six months, union has not taken place in spite of retention in good position, then I believe that operative interference is indicated. Bone plates I find of little use in such conditions. A bone plate, it has been very well demonstrated, delays union. In these cases of non-union the best procedure, in my opinion, is an actual bone graft, either taken from the tibia of the patient or from the upper part of the fracture in question. The result from this method is most gratifying.

2nd. In considering fractures in and near joints I shall try and take a few of the specific instances and apply certain principles.

(*a*) Fractures of the upper humerus. Fractures of the head of the humerus may be very simple or comminuted. When comminuted, or where there is considerable malposition, open reduction may be undertaken with little danger, and the fracture immobilized in abduction by means of plaster spica from the fingers to the chest. When there is any dislocation of the head, operative interference is always indicated. Deformity near the shoulder joint will limit antero-posterior motion some, and abduction and external rotation a great deal. Therefore the replacement of these fragments and the placing of the arm in abduction not only insures return of these motions but also lessens the danger of that frequent complication of shoulder fracture, sub-deltoid vursitis or periarthritis, which gives long and painful disability.

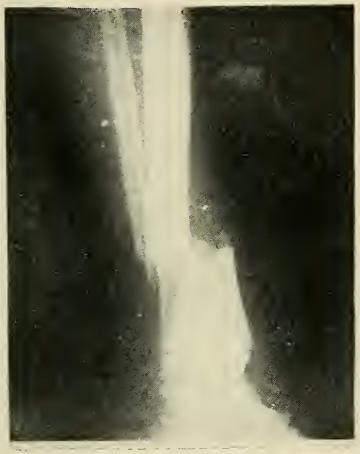
(*b*) Fractures of the lower humerus. Fractures of the lower humerus, especially in childhood, give fairly satisfactory results providing flexion is used. The displacement when the fracture is complete is usually through the line of the epiphysis or just below through the condyles. This fracture is treated in the hands of some surgeons by reduction and retention in a right angle splint. This is to be severely condemned. There is one anatomical position which may be depended upon to hold reduction, acute flexion. Do not expect acute flexion to reduce the deformity. It will help, but strong traction and a direct forward pull should certainly be used and then acute flexion will hold the reduction. Swelling of the hands occurs in unreduced cases, very rarely because the flexion is too acute.

In unusual cases, with rotation of fragments or other "irreducible" deformity, it has been most gratifying to see results from a small external incision, and after a proper understanding of the type of fracture the absolute anatomical reduction of the same by means of the gloved finger and blunt dissector; the fragments can be replaced so that the fracture line looks like a piece of cracked china. There is no danger in this method of injuring vessels or nerves. Here probably, more than any other joint in the body, is a joint which will not take care of excessive callus and therefore demands complete reduction of deformity.

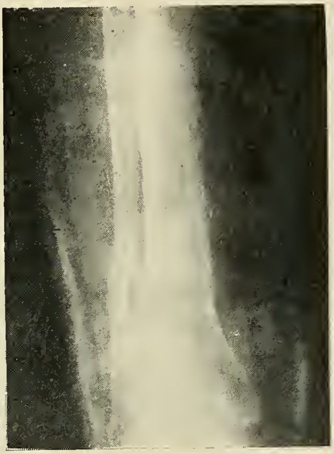
Another common type of fracture is that of the head of the radius. If a simple fissure and in perfect position, the usual treatment is all that is necessary. You see quite a number of working men with fracture of the radius with slight displacement, which, like fracture of the carpal and tarsal scaphoid and semilunar, give great pain through a long period of time although fairly good motion may be present. These fractures in working men do better with excision of the head of the radius. Fractures of the lower end of the radius, or Colles' fractures, have done well under conservative methods and very seldom require opening. By ether and early manipulation these fragments can be placed forward and held in position. If the fragments can be held in position and at the same time the hand hyper-extended in the splint in the position of strength, a great many of the stiff fingers and stiff wrists will be avoided. This position is the "strong" position for the wrist in all lesions about the joint. Fractures of the scaphoid and semilunar are often overlooked. They frequently cause very little immediate disability. In diagnosis, weakness of the hand following an injury may be the only clue. Sometimes the X-ray does not show if not taken in a certain plane. Excision of part or all should always be considered.

A consideration of fractures in the hip joint might well occupy a full hour for discussion. Probably no fracture has been so long poorly understood and badly treated. Largely mistakes have been due to traditional teaching and writing and the ordinary treatment in surgical clinics. Fracture of the neck of the femur always means deformity. This deformity may be slight or may be great, but whether slight or great requires reduction. In the traditional treatment reduction has not been the object in view, and even retention of the fracture or immobilization has been ill accomplished by the ordinary means. Compare, for a moment, the patient, his comfort, his ability to move, and his general happiness with the ordinary treatment and with the reduction after the Whitman method and the application of a long plaster spica.

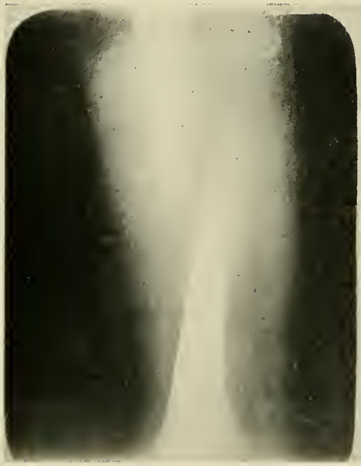
Under the older methods of treatment the Buck's traction apparatus or some form of splint has been in use for immobilization. In most cases they did not immobilize. Hence it is easy to understand that patients so treated suffer pain in the movement and live in constant dread of any necessity for lifting them about, as is demanded in ordinary nursing and care. Is it any wonder that the older patients with these fractures rapidly become discouraged, and, losing strength and resistance, die? Compare the patient so treated with a patient in a plaster spica, with the fragments completely reduced and fixed in strong abduction. Pain as a factor is eliminated, for in the first place there is no deformity, and in the second place fixation is good. We have therefore obeyed two of the fundamental laws in treating fractures.



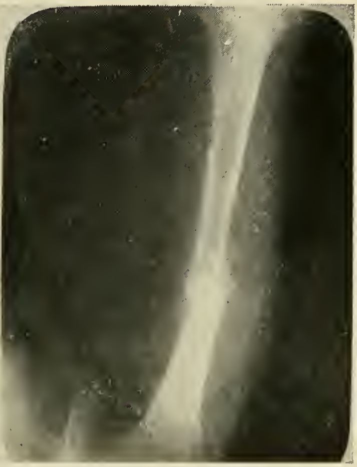
LEARY. Fracture both bones leg before operation. Note serrations.



Following open reduction, anatomical reposition.



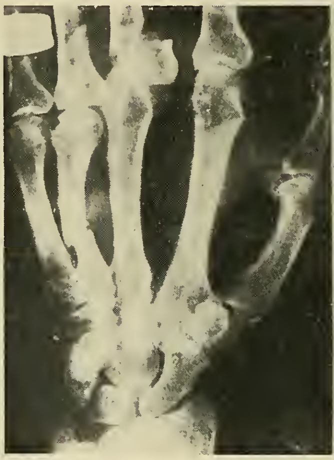
Fractured femur in child before operation. Note serrations.



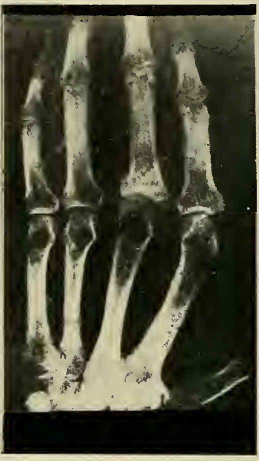
After operation.

Let me run over, for a moment, the various steps in the abduction method of treating these fractures of the hip.

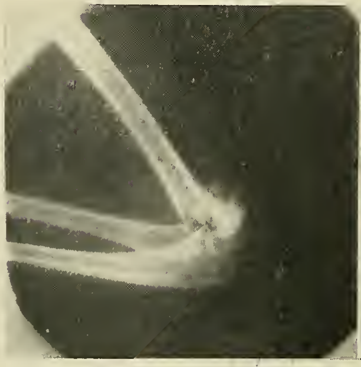
First, traction reduces the overriding, the trochanter is carried well forward, reducing the backward displacement, and then by inward rotation and strong abduction the fragments are held in close apposition. Non-union by such a method is comparatively rare. Deformity or malposition is even more rare, and the slow, painful hypertrophic changes which take place about the hip joint when badly treated are not seen. The patient in the spica may sit up on the edge of the bed



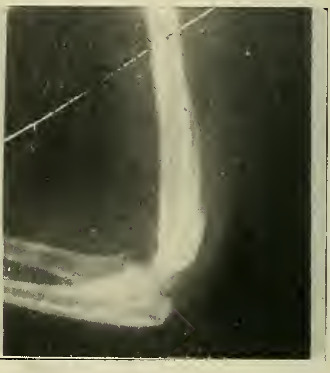
CHEEVER. Fractured 4th metacarpal. Fracture-dislocation of base of proximal phalanx, middle finger.



Following open reduction and replacement of fragments with blunt dissector. Note absence of callus.



Fracture lower epiphysis of humerus with displacement backwards.

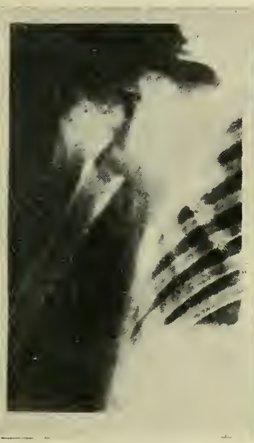


After operation. Anatomical replacement. Note callus formation up outer side of humerus due to tearing of periosteum and hemorrhage.

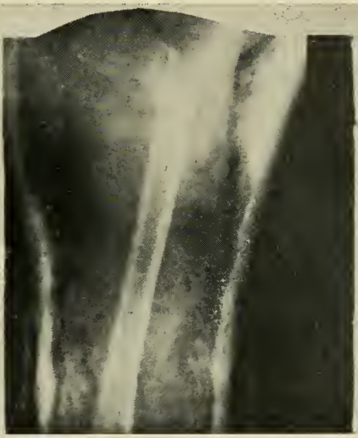
a few hours after its application, may stand and walk with crutches as soon as able to and may walk upon the injured leg after three or four weeks, and, best of all, may look forward to a result which does not leave him a permanent cripple.

3rd. Fractures of the spine I shall allude to merely to point out a few interesting features. In the first place these fractures are very frequently overlooked. Even in children their frequency is surprising. In the past year three cases have come to my attention of fractures of the spine which were undiagnosed until looked for.

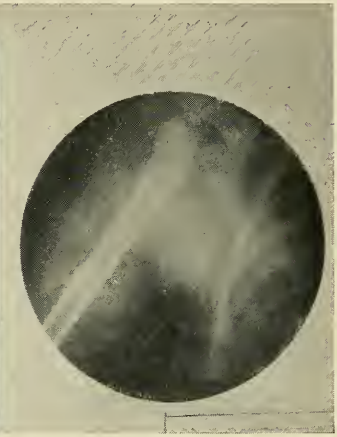
Transverse processes are frequently broken by direct or muscular



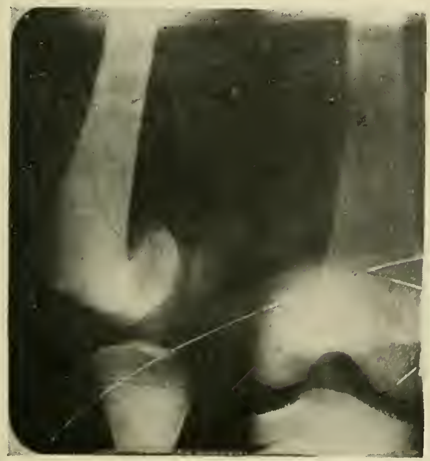
MOSES. Fracture upper end of humerus before manipulation.



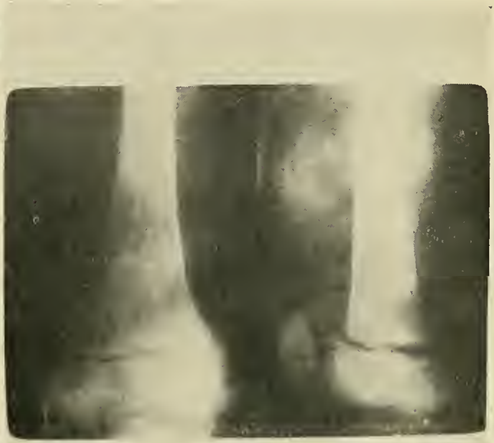
Position after attempt had been made to place fragments in proper position by manipulation alone.



Anatomical position following open reduction with aid of blunt dissector.



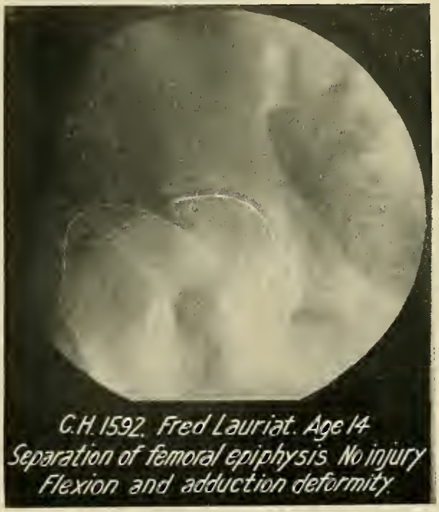
Fracture lower epiphysis before operation.



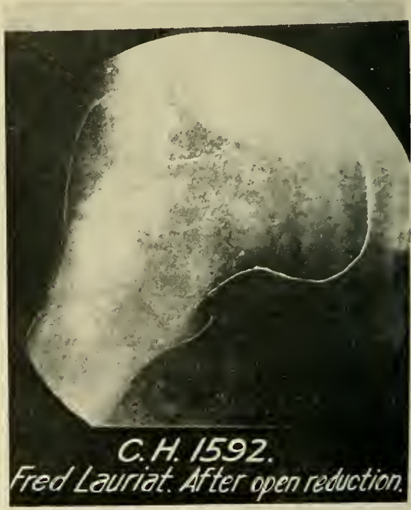
McMURRAY. After replacement by means of blunt dissector through incision.

violence and cannot be recognized from the history alone. X-ray is a determining diagnostic point. All such fractures should be treated either by hyper-extension on a frame or in a well fitted plaster jacket.

Just a few words, in closing, in regard to operative interference in the treatment of fractures. The time of choice, in my opinion, is not immediately after the injury but after a week or ten days. Strict surgical asepsis and an unusual amount of mechanical skill are very important factors. The ordinary asepsis and even the ordinary hemostasis is not sufficient in this field of surgery. All skin edges should be kept covered; no knife or instrument that has touched the skin should be used in the deeper tissues. Blunt dissection is a valued means of approach to most fractures and I do not hesitate to use my gloved fingers in separating muscles, since I feel that manipulation is gentler and more accurate than when instruments are used.


C.H. 1592. Fred Lauriat. Age 14
Separation of femoral epiphysis. No injury
Flexion and adduction deformity.

Separation of femoral epiphysis, no history of injury, before open reduction.



LAMENT. Anatomical replacement after open reduction.

Lane's plates and the use of various non-absorbable material to hold reduction is, in my opinion, to be studiously avoided. The indiscriminate use of plates has brought their use into disrepute. There is no doubt but what in an occasional place the Lane's plate has a distinct field, but with a little ingenuity in the placing of the fragments and in the use of absorbable material and carefully made supports, non-absorbable materials will not be found necessary.

This paper has rather hastily and incompletely covered a very large field, and if the few principles which I have tried to represent to you will help in standardizing the judgment which we all find so difficult I shall feel that I have accomplished my purpose. Some of the points brought forward I can illustrate by some lantern slides which are to follow.